Odor Identification and Control

Central Wastewater Treatment Plant

Metro Water Services

Metropolitan Government of Nashville and Davidson County

Final Report

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Table of Contents

Section 5 – Requirements for Odor Abatement

Section 6 – Conclusions and Recommendations

Executive Summary

Traditionally, odors emitted from treatment plants have been considered a necessary evil of treating wastewater. Most treatment plants were located in relatively isolated or industrial areas, resulting in little concern for the adjoining property owners. As communities expand, the areas around the wastewater treatment plants have become more populated, and control of odors has become a priority.

Metro Water Services has long been aware that odors from the Central Wastewater Treatment Plant (WWTP) have been a problem in the surrounding community. Beginning in the early 1990s, Metro Water followed a policy of providing odor control for new construction at any unit process that was considered to be a potential odor source. By the late 1990s, it was apparent that this policy was not resulting in any significant improvement in the odor problem. Metro Water Services determined that in order to be a good neighbor, the commitment would be made to address off-site odors comprehensively – and to approach the problem in an analytical manner to ensure resources are invested efficiently.

In late 2001, the odor evaluation was started. The project team consisting of Jordan Jones & Goulding, Huber Environmental and Metro Water Services, began to evaluate each unit process at the Central WWTP for odor sources.

The first step of the evaluation was to conduct public meetings to inform citizens about the study procedure and objectives. In addition, a focus group consisting of several residents of the area impacted by the odor problem was established. The focus group was informed about the details of the study throughout the process and had the opportunity to provide input where appropriate.

The next step of the evaluation was to identify all potential odors sources. Each of these sources was then sampled. Point sources (fans, pipes and vent stacks) were sampled by pumping the odorous air directly into a special sampling bag. Area sources (open tanks) were sampled by floating a specially designed hood on the water surface and pumping the odorous air into the sample bag. The sample bags were then shipped overnight to Atlanta for sensory analysis.

Odor is a threshold science. Every odor has a threshold concentration, which is the concentration at which the odor can barely be detected. By determining how many dilutions of fresh air are needed to reduce the concentration of an odor to the threshold concentration, the relative strength of the odor can be determined. This relative strength is expressed as the dilution to threshold ratio (D/T). A panel of people who have been evaluated to determine their sensitivity to odors was used to evaluate the odor samples. For each sample, the relative strength of the odor (D/T) was determined as well as the odor's tendency to linger in the environment.

For each odor source, an exhaust rate was also determined. The exhaust rate is the volume of odor released. When the exhaust rate is multiplied by the D/T, which is an odor concentration, the result is the emission rate, which is the mass of odor generated by the source per unit of time.

The odor emission rates were used in a computer model to determine how far from the treatment plant each odor source would transport. The transport distances were then used to rank each odor source, since the odors that transport the farthest from the treatment plant must be controlled first.

The objective of the project was to prevent any odor source from crossing the property line of the facility. Each odor source that exceeded the objective was included in recommendations for control, and the amount of odor reduction required for each source to meet the property line objective was determined. The odor sources recommended for control in priority order are shown in Table ES-1.

From the odor reduction requirements, a list of possible alternatives was developed. This list included the following types of control alternatives:

- Housekeeping changes - improvements in housekeeping that can result in odor reduction. These items can include more frequent wash down, removal of floating objects from basins, and other similar items.

Table ES-1
Odor Sources – Central WWTP

Odor Source	Control Method
Total Dewatering Building	Included in Bio-solids project
Total North Scrubber Exhausts	Structural – previously covered, change treatment technology
Total North Primary Clarifiers	Structural – cover and treat
Aeration Basins	Process change
South Primary Clarifiers	Process change
Primary Effluent Channel	Structural – cover and treat
Aeration Influent Channel	Process and housekeeping change
Screw Pumps	Structural – cover and treat
Old Grit Channel	Abandon if possible

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- Process changes – changes in the way that the treatment plant is operated. These types of changes can include taking basins out of service, increasing aeration or adding chemicals

- Structural changes – improvements that require construction, such as covering basins and treating the captured odors.

Many alternatives are available for odor treatment, but only two are practical for treating large volumes of air. The two alternatives are packed bed scrubbers and bio-filters. Packed bed scrubbers remove odors by chemical treatment. They are generally less expensive to construct, but more expensive to operate because of the chemical costs. Bio-filters use bacteria to remove odors. Because bio-filters use a naturally occurring process, the operating costs are low, but they are more expensive to build.

The following housekeeping changes are recommended for the Central WWTP:

- Aeration Influent Channels - Remove debris from the influent channel to the aeration basins on a more regular basis.
- Final Clarifiers - Control scum on the final clarifiers. If scum does form, remove the scum as soon as possible.

Process changes are also recommended. They include:

- North Grit Chamber Influent – Change operation of the Brown's Creek Pump Station force mains to reduce peaks of hydrogen sulfide at the North Grit Chamber.
- Aeration Basins – Control the dissolved oxygen levels in the aeration basins to prevent low dissolved oxygen and formation of scum.
- South Primary Clarifiers – Limit use of the South Primary Clarifiers as much as possible. If the use of these clarifiers cannot be limited, consider odor control.
- Aeration Influent Channel – Eliminate channel aeration in the Aeration Influent Channel, and reevaluate odors if necessary.

Areas recommended for structural control of odors include:

- North Grit Area
- Primary Clarifiers, including the influent channel, quiescent area, weir area, and effluent channel.
- Screw Pumps
- Sludge Dewatering Buildings.
- Old Grit Channel, if the channel cannot be abandoned.

Evaluation of the alternatives for structural odor control used net present value (NPV) so that the impact of operating cost was included in the evaluation. NPV is the sum of the construction, or capital, cost of the alternative plus the amount of money that would be required in a savings account today to fund operation of the alternative for the next 20 years. Table ES-2 lists the scrubber alternative and the bio-filter alternative that are the most cost effective and allow the greatest ease of operation and their NPV.

Based on the analysis of the alternatives, one bio-filter to treat all of the odor sources from the liquid treatment processes is recommended. This alternative has the added benefit of being the most environmentally responsible alternative because a naturally occurring process will be used to reduce odors. The estimated capital cost for the recommended alternative is $11,798,000.

Treatment of odors from the solids treatment processes will be included with the proposed bio-solids improvements project. The bio-solids project will replace the existing sludge dewatering processes with new anaerobic digesters for sludge stabilization, new dewatering facilities and a heat drying facility.

Table ES-2
Net Present Value Comparison

Description	Capital Cost $	Operating Cost $/year	Net Present Value $
Two scrubbers in separate locations for the liquid train	9,259,000	754,000	18,653,840
One bio-filter for the liquid train	11,798,000	206,700	14,373,482

Section 1
Introduction

The Central Wastewater Treatment Plant (WWTP), owned and operated by Metro Water Services serving Nashville – Davidson County, treats primarily domestic wastewater and storm water from a large portion of the Nashville metropolitan area, including the downtown combined sewer system. The facility is permitted under the National Pollutant Discharge Elimination System (NPDES by the State of Tennessee.

1.1 - Facility Location and Description

The WWTP is located on Second Avenue North, just inside the downtown loop. The facility is bounded on the north by I-65 (formerly I-265), on the east by the Cumberland River, on the south by Van Buren Street and on the west by Third Avenue, North.

The current rated capacity is 100 million gallons per day (MGD) during dry weather and 330 MGD during wet weather. The plant is designed to treat wide variations in flow because of the combined sewer system.

The Central WWTP incorporates many unit processes for the purpose of treating wastewater. The facility description can be separated into discussions for the liquid train and solids train. In order to help define some of the terminology that will be used in subsequent sections of this report, the individual unit processes, following the flow path of the wastewater, are discussed as follows:

- Liquid Train - The group of processes treating the wastewater from the point that it enters the facility to the point where it is discharged is called the "liquid train."
- Solids Train - During the treatment process, solids are removed from the wastewater. These solids are further treated in the "solids train."

1.1.1 - Liquid Train

Incoming Wastewater – The wastewater enters the facility via two systems. About half of the dry weather flow to the treatment plant originates from the downtown combined sewer area. These sewers flow by gravity into the Central Pump Station, which is located at the wastewater treatment plant site. The remaining half of the dry weather flow comes from the separate sanitary sewer system. The majority of this flow is pumped to the North Grit Chamber by the Browns Creek and the 28th Avenue Pumping Stations.

Some of the various pumping stations that are in the area served by the Central WWTP have the capability of adding chemicals to the wastewater in the attempt to minimize corrosion and odors in the transmission pipelines.

Central Pumping Station – The pumping station has an open section followed by an enclosed wet well (where wastewater enters the pumping station). The open portion has a thick scum layer that tends to contain any odors from the wastewater. The air from the wet well is exhausted to an odor control scrubber.

Flow from the Central Pumping Station is pumped to the South Grit Chambers during wet weather. During dry weather, the flow can be pumped to either the North Grit Chambers or the South Grit Chambers. Normally, the South Grit Chambers are taken out of service during dry weather.

Central Pumping Station Scrubber System – The Central pumping station scrubber system is actually two systems installed on opposite sites of the pumping station. Each system is comprised of two stage mist scrubbers.

At the present time, only one side is operational due to a previous fire which occurred in the duct system.

Preliminary Treatment - These are the first major treatment process at the WWTP. Unit processes associated with preliminary treatment are:

- Grit Removal - Grit is heavy solid material such as sand and gravel. The grit removal is accomplished in aerated grit chambers. The grit that is removed from the wastewater is disposed in grit bins and then disposed off site. Grit removal is performed to protect wastewater treatment equipment further downstream in the liquid train. Central WWTP has two sets of grit chambers. The North Grit Chambers are always in operation. The South Grit Chambers are normally only operated in wet weather. Both sets of grit chambers are covered and the air within the enclosures at the South Grit Chamber is vented to the South Grit Scrubbers (see later discussion). The air within the enclosures at the North Grit Chamber is vented to the North Grit scrubbers– (see later discussion). Screening - The wastewater is screened in the South Grit Chamber in order to remove any debris that may have entered the combined sewer system. As is the case with the grit, screenings that are removed are disposed in a screenings bin. The screens are enclosed. Only the discharge from the South Grit Chambers is screened. The wastewater that flows directly to the North Grit Chambers is screened prior to reaching the remaining portions of the treatment facility.

South Headworks Scrubber System – The south headworks scrubber system is comprised of one two stage packed bed scrubbers and two single stage packed bed scrubbers. Since the south headworks is operated intermittently, only during wet weather events, the scrubber systems are only operated when the system is operating.

North Headworks Scrubber System – There are four two-stage mist scrubbers serving this area. Two of the systems serve the aerated grit tanks, one serves the grit tank influent and the fourth serves the general building ventilation.

Primary Influent Channels – The primary influent channels convey the wastewater from the grit chambers to the primary clarifiers. These channels are quite long and incorporate aeration in order to maintain solids in suspension. The channels are open to the atmosphere.

The North Primary Influent Channel conveys all dry weather flows to the north primary clarifiers and is in operation all of the time.

The South primary influent channel is only used when the south grit system is in service, and conveys flow to either the south primary clarifiers or the north primary clarifiers. In this report, this channel is termed the “transfer channel”.

Primary Clarifiers – The primary clarifiers are rectangular basins used to settle solids from the wastewater. The basin can be divided into two portions:

- Quiescent Zone – As this would suggest, this zone, which comprises the majority of the area of the tanks, is where the settling occurs.
- Weir Area – At the end of the tank, the wastewater flows over weirs located on clarifier surface. This area has more turbulence than the quiescent zone.

The primary clarifiers are open to the atmosphere.

Solids removed from the primary clarifiers are pumped to the sludge holding tank.

The Central WWTP has two sets of primary clarifiers – the north primary clarifiers and the south primary clarifiers. The north primary clarifiers are used all of the time, while the south primary clarifiers may be taken out of service during dry weather.

Primary Effluent Channels – These channels convey the wastewater from the primary clarifiers to the screw pumps.

These channels are open to the atmosphere and are always in service.

Screw Pumps – The screw pumps lift the wastewater up to the level of the aeration tanks. There are two banks of screw pumps. All of the screw pumps are open to the atmosphere.

Aeration Tanks - The aeration tanks are part of the biological treatment process. Bacteria are grown in the aeration tanks for the purpose of removing the dissolved organics in the wastewater. Since the bacteria require oxygen (aerobic process), air is added to the basins via draft tubes. The draft tubes use a mixer to add air to the tanks and keep the tank contents well mixed.

Return Activated Sludge (RAS) is also pumped to the inlet of the aeration tanks. The RAS recycles bacteria from the final clarifiers back into the aeration basins.

As in the case of the primary clarifiers, these tanks are open to the atmosphere.

Mixed Liquor Channels – These channels convey the mixture of wastewater and bacteria (mixed liquor) from the aeration tanks to the final clarifiers.

This channel is open to the atmosphere.

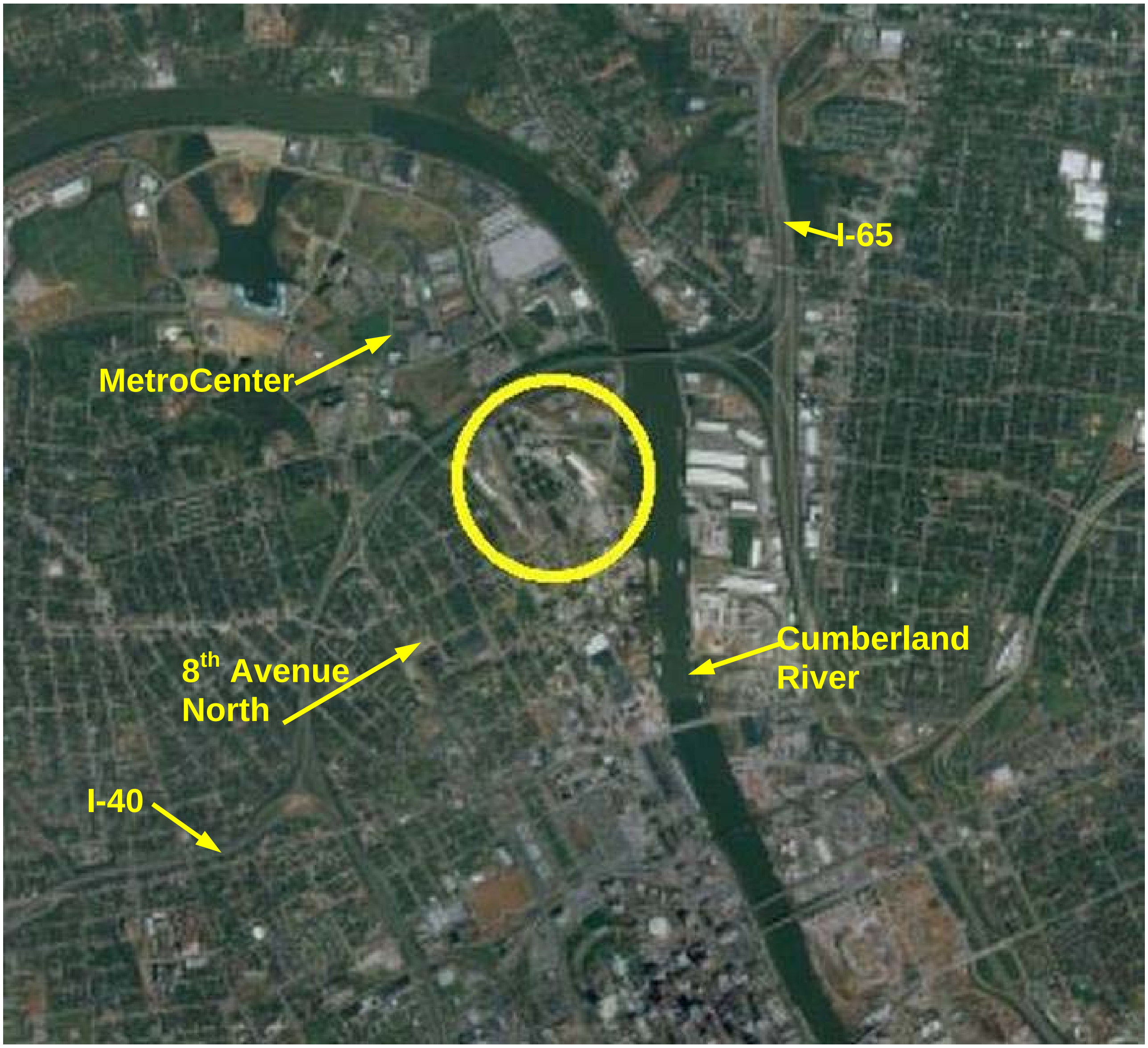

Figure 1.1
Central Wastewater Treatment Plant

Figure 1.2
Central WWTP Site Plan

Final Clarifiers - The wastewater leaving the aeration tanks contain a high concentration of solids. Much of these solids are the bacteria that were grown in the aeration tanks. The final clarifiers act to remove the bacteria via settling.

Whereas the primary clarifiers were rectangular, the final clarifiers are circular. The quiescent zone is located in the center of the tank and the weir area is around the periphery of the tank.

Most of the solids that settle in the final clarifiers are recycled to the aeration basins as RAS. Because the bacteria in the aeration basins are consuming organic material, they are growing and reproducing. In order to keep the bacterial population in balance with the amount of food available, a certain amount of bacteria must be removed from the system on a regular basis. The portion of the solids that are removed from the system is called waste activated sludge (WAS). The WAS is pumped to the thickened solids wetwell.

These tanks are also open to the atmosphere.

The aeration tanks and final clarifiers comprise the secondary treatment portion of the WWTP. The wastewater has been substantially treated by the time it leaves the final clarifiers.

Extremely high flows in the secondary treatment portion of the plant can cause problems such as washout of solids and reduced treatment efficiency. For this reason, flow through the secondary treatment process is limited. When the flow to Central WWTP increases above 250 MGD, all flows over 250 MGD are diverted at the south primary clarifiers and routed directly to the wet weather unit for disinfection.

Disinfection - The final process in the liquid train is disinfection. Chlorine is added to the treated wastewater in the chlorine contact chamber to kill any residual bacteria that remains in the wastewater. After disinfection, the chlorine is removed from the wastewater prior to the wastewater being discharged.

Central WWTP has three chlorine contact chambers. One of these chambers is referred to as the wet weather unit, and is used only during wet weather to disinfect high flows that are diverted directly from the south primary clarifiers.

1.1.2 - Solids Train

There are fewer processes in the solids train, but they are just as important. The solids originate from both the primary and final clarifiers. In addition, the solids from the White’s Creek WWTP are transported to the Central WWTP for processing.

Solids Thickeners – The thickeners are used to remove a portion of the liquid from the solids. The WAS from the Central aeration basins as well as the solids from the White’s Creek WWTP are combined in the thickener wetwell. The combined solids are then thickened with gravity belt thickeners and discharged to the thickened solids storage tank. The content of this tank is pumped to the solids holding tank.

The solids thickening building presently incorporates some odor control. However, the scrubber is quite old and is marginally functional.

Solids Holding Tank – This tank holds the solids prior to further processing. The solids from the thickened solids holding tank and the solids from the Central primary clarifiers are combined in the solids holding tank. The tank has a very small volume and is open to the atmosphere.

Solids stored in the solids storage tanks are pumped to the dewatering buildings for solids dewatering.

Solids Dewatering – The solids from the primary and final clarifiers are mixed together for treatment and dewatered within the solids dewatering building via belt filter presses.

Central WWTP has two dewatering buildings. One building is commonly referred to as the Incinerator Building because it once housed an incinerator that burned the solids. It contains eight belt presses. The second building is commonly known as the Ash Building because it was once used to store ash from the incineration process. It contains two larger belt presses. Neither building is equipped with odor control.

Chemicals are added to the solids prior to dewatering to aid in the dewatering process. In addition to chemicals added for dewatering, an oxidant could also be added for the purpose of minimizing odors within the dewatering building. However, the facility does not have permanent facilities for chemical feed.

The dewatered solids are conveyed via a conveyor to a truck located outside of the dewatering buildings.

Future Construction – Presently there are plans to add new thickeners, anaerobic digestion and centrifuges to the facility. This system would replace all of the existing solids handling facilities (see later discussion).

1.2 – Objectives

In August of 2001, a study was initiated at the WWTP to determine the source(s) of the odors being emitted to the neighboring areas and to determine alternatives for odor abatement. The objectives of this study were to:

1. Determine the specific source(s) of odors that could be impacting the surrounding neighborhood.
2. Determine the degree of removal necessary for each problem source to minimize or eliminate the odors leaving the property.
3. Evaluate alternatives for odor abatement for each source.

4. Evaluate the impact of the proposed improvements on odor emissions.

This report includes the following:

1. Discussion of the methods used for determining the sources of odors.
2. Interpretation of the data.
3. Problem odor source definition.
4. Requirements for odor abatement.
5. Alternatives for odor abatement.
6. Conclusions and recommendations.

1.3 - Odor Study Approach

1.3.1 - Odors

Odors can occur from waste treatment facilities due to many factors:

1. Odor Producing Pollutant Development in the Wastewater - Wastewater that is discharged from residents, commercial, business and industry will have odor causing constituents. The type of odor causing compounds will vary depending on the source. Odorous compounds can be volatile or semi-volatile organics in addition to sulfur and nitrogen based compounds.

2. Conditions in the Incoming Sewers - All wastewater has the potential for odor production. The degree of odor production is dependent on conditions that exist in the sewers. In sewers that have a "slow" rate of flow, the wastewater has the potential to become anaerobic (no or very low oxygen). This condition occurs especially during warm summer months. Sulfur compounds, typically in the form of sulfates (SO_4), are reduced under anaerobic conditions. This reduction causes the formation of dissolved sulfides. Dependent on the chemistry of the wastewater, a portion of the dissolved sulfides will be in the form of hydrogen sulfide (H_2S). The H_2S in the liquid phase remains in equilibrium with the H_2S in the atmosphere above the liquid surface. The amount of H_2S released will be dependent on the atmospheric pressure and other factors occurring at the time. H_2S has a very low odor threshold value (explained later) and, therefore, can be a significant odorant.

3. Waste Treatment Processes - In addition to the types of materials in the incoming wastewater and the conditions occurring in the sewers, the waste treatment processes themselves can produce odors. This is valid for both processes associated with the liquid and with the solid trains. Odors can be produced by the addition of chemicals to the liquid train as well as by specific unit processes, such as sludge holding and dewatering. Typically, odors from the liquid train are very minimal during wet weather flows.

Due to the number of possible causes for odor production at the WWTP, there are many odor-causing compounds that could exist. This possibility accentuates the problem of "locating" a specific source of odor generation. The measurement of only one pollutant (typically H_2S) can lead to invalid conclusions when studying odor problems.

The occurrence of an odor "problem" involves many steps:

1. Odor Source - There needs to be an odor source. In a treatment facility such as the Central WWTP, there are many potential sources of odors from both the liquid and solid trains.
2. Odor Release - Although potential odor sources may exist, if that odor is not released to the atmosphere, the odor cannot become a problem. Many of the unit processes described above have the potential for off-gas release. These release points can be:
   - Tanks and channels
   - Aerated tanks
   - Static vents
   - Fan exhausts
3. Odor Transport - Although there may be an odor source and the possibility for that odor to be released, the odor needs to be transported off-site to cause a possible odor problem. This odor transport is totally dependent on meteorological (weather) conditions.
4. Presence of a "Receptor" - A "receptor" is defined as a human nose. Without the presence of a receptor, even though the odor has been released and transported, no odor problem would exist. Historically, when treatment facilities were constructed away from residential and/or urban development, odor problems did not occur, simply because no receptors were present to become aggravated by the problem. As urban areas became more densely populated, more receptors were present and, therefore, the odor problems began to occur.

It has been assumed in this study that all of the above steps have to be present for an odor problem to occur. This is an important assumption in that an odor at the WWTP that is not transported to a receptor is not considered an odor problem.

1.3.2 - Study Approach

The approach taken during the odor study included the following steps. In many cases the results of a preceding step dictated the action of the subsequent step. In general however, the following approach was taken:

1. Identification of All Potential Sources - The WWTP was toured and plans and specifications were reviewed to determine all potential odor release points.

2. Sampling of All Release Points - All potential sources identified in Step 1 were sampled.
3. Evaluation of Samples - The samples collected in Step 2 were evaluated by two methods:
   - Sensory evaluation, and
   - Specific pollutant evaluation
4. Data Interpretation and Ranking - All data from Step 3 was interpreted and ranked in order of most significant to least significant.
5. Screen Modeling – The data determined most significant from Step 4 was computer modeled using an EPA approved air dispersion model. The results of this modeling indicated the potential for a specific odor to travel off-site.
6. Establishment of Objectives - Objectives were established which dictated the degree of removal required from each problem source.
7. Determination of Required Percent Removals - Based on the objectives established in Step 6, and the screen modeling results (Step 5), the percent removals were determined for each problem source.
8. Alternatives Evaluation – Alternatives were reviewed which would meet the objectives and associated required percent removals.
9. Conclusions and Recommendations - Based on the work performed in the steps above, conclusions were reached as to the sources of odors that are or could reach receptors and the available alternatives for odor abatement.

The format of this report follows the steps taken in the odor study. Presented herein are the results from the study, the methodology.

1.4 – Focus Group

A focus group was formed comprised of residents of nearby neighborhoods. The group met three times in the evenings.

The objectives of the focus group were as follows:

- Monitor the process and schedule.
- Provide input in establishing an abatement objective.
- Provide advice related to abatement strategies.

In addition to the above, members of the focus group maintained odor occurrence logs. These logs were used to triangulate odor sources.

The agendas for the meetings and those taking part in the focus group are included in the appendices of this report.

Section 2
Initial Facility Investigations

2.1 - Facility Inspection

In September of 2001, the Central WWTP was inspected in order to become familiar with the facility and to identify all potential odor sources and release points from the unit processes within the facility. Observations made during the inspection were the basis for further investigation of odor sources. Table 2.1 presents all of the potential release points identified during the inspection.

Table 2.1
Odor Release Points
Central WWTP

Unit Process	Sub Area	Comments
North Grit Removal	Scrubber Exhausts	Four Scrubbers – Inlet / Outlet
South Grit Removal	Scrubber Exhausts	Two Scrubbers – Inlet / Outlet
	Grit Channel	-
Central Scrubbers	Scrubber Exhausts	One Scrubber Out of Service
North Primary Clarifiers	Influent Channel	-
	Quiescent Area	-
	Weir Area	-
	Effluent Channel	-
South Primary Clarifiers	Quiescent Area	-
	South Transfer Channel	-
Screw Pumps	Sump Area	
Aeration Tanks	Aeration Influent Channel	-
	Aeration Basins	Aerobic and Anoxic Zones
	Mixed Liquor Channel	-
Final Clarifiers	Quiescent Area	-
	Weir Area	-
Solids Processing	Thickener Wet Well	-
	Thickener Bldg. Exhaust	-
	Thickened Solids Storage Tank	-
	Bldg. Exhausts	Three Bldgs – New, Old and Auxiliary
	Centrate Channel	-

3.1 – Sampling Locations and Sample Types

Samples were collected from all potential odor release points shown in Table 2.1 beginning in August 2001. Sampling occurred through September and October 2001.

There are three different types of sources:

- Point source discharges - Point sources are sampled by placing the suction line of a peristaltic pump directly into the discharge of the vent or exhaust.
- Area sources (no air addition) - These are sources such as open tanks and channels that do not have aeration or other forms of air addition. Sampling of area sources is accomplished by the use of an equilibrium chamber, called a floating emission sampler (FES). When floated on the water surface, the FES forms a trapped air space with a surface area of approximately three (3) square meters. An airflow rate per unit area is established by the peristaltic pump's pumping rate. The airflow rate used in setting the peristaltic pump was determined by the expected evaporation or exhaust rate.
- Area sources (with air addition) - These sources are similar to the area sources described above except that the tank has air addition. The only difference in sampling these sources versus sources with no air addition is the airflow rate of the peristaltic pump. An attempt is made to match the airflow rate of the pump with the airflow rate entering the tank.

Table 3.1 indicates the sampling locations for the source locations shown in Table 2.1. In addition, the sample date and type of sample are provided.

3.2 - Sampling Procedures

For all of the above locations, air samples were collected in Tedlar bags through Tygon tubing. Tedlar sampling bags were used due to their resistance to retention of odorous compounds. Each bag was pre-conditioned with a sample of the off-gas stream to be evaluated and then evacuated before starting the sampling. Bags were filled to approximately 75 to 80% of capacity.

For all of the sources, equipment was rinsed and cleaned between each sampling. ASTM procedures for air sampling were followed during the sample collection activities. Samples were presented for sensory evaluation within 24 hours after collection. In addition to samples collected as indicated above, field measurements of hydrogen sulfide (H_2S), mercaptans and ammonia were also taken. These measurements were taken concurrently with the odor sample collection. A Jerome 631-X gold film auto-ranging H_2S analyzer was used to measure the hydrogen sulfide and Draeger tubes

Table 3.1
Sample Locations
Central WWTP

Location	Sample #	Date	Sample Type
N. Scrubber System #1 – Inlet. mid-stage and exhaust	1,2,3	9/5/01	Point
N. Scrubber System #2 – Inlet, mid-stage and exhaust	4,5,6	9/26/01	Point
N. Scrubber System #3 – Inlet and exhaust	7,8	9/3/01	Point
N. Scrubber #4 – Inlet, mid-stage and exhaust	9,10 35,36,37 53	9/3/01 10/1/01 10/22/01	Point
S. Scrubber System #1 – Inlet, mid-stage and exhaust	32,33,34	10/1/01	Point
S. Scrubber System #2 – Inlet, mid-stage and exhaust	29,30,31	10/1/01	Point
Central Scrubber System – Inlet, mid-stage and exhaust	49,50,51,52	10/22/01	Point
Old Grit Channel	44	10/3/01	Area
Primary Influent Channel	11	9/3/01	Area
N. Primary Clarifier – Quiescent Zone	12	9/4/01	Area
S. Primary Clarifier Quiescent Zone	13	9/4/01	Area
N. Primary Effluent Channel	14	9/5/01	Area
North and South Screw Pumps	15,16	9/26/01	Area
N. Aeration Influent Channel	68	10/22/01	Area
N. Aeration Basins	17,18,19 20,21,22,23,24	8/29/01 9/25/01	Volume
N. Mixed Liquor Channel	25 26 38	9/25/01 8/29/01 10/2/01	Area
Final Clarifiers – Quiescent	39	10/2/01	Area
Thickener Wet Well	40	10/3/01	Area
Thickener Bldg. Exhaust	41	10/3/01	Point
Solids Storage Tank	47	10/8/01	Area
Dewatering Bldg. Exhaust	42,43 45,46 54,55	10/3/01 10/8/01 10/22/01	Point
Dewatered Solids	48	10/16/01	Area
Centrate Channel	56	10/22/01	Area

were used to measure mercaptans and ammonia.

3.3 - Sensory Evaluation

3.3.1 - Odor Panel Selection

The air in the Tedlar sample bags was submitted to an odor panel, located in Atlanta, Georgia, for sensory evaluation. Ten (10) individuals served on the odor panel. All panelists had been previously screened to determine their sensitivity to various odor thresholds.

3.3.2 - Sensory Analysis Procedures

3.3.2.1 - Odor Concentration

The forced choice triangle principle was used to determine the odor threshold of samples collected at the WWTP. A dynamic olfactometer served as the device to supply six serial dilutions of

Figure 3.1
Central Sample Points

odor sample to the panelist. Each panelist was presented three samples (triangle principle) at each dilution level and was asked to select the sniffing port that contained the odor. Two of the ports discharged non-odorous air. The panelist was asked to make a judgment (forced choice principle) as to which port delivered the odor. If no odor was distinguished, the panelist was instructed to make a guess.

The forced choice triangle procedure was used to eliminate the problem of handling false-positive data generated by other techniques that involve selection based on odor/no odor responses. Each panelist progressed from the port containing the most diluted sample toward those with higher concentrations until all six dilutions were administered. Response at each sample port was recorded. Data was later interpreted by a statistical procedure to determine the D/T value for each sample.

D/T is defined as the effective dosage at the 50% level; that is, the dilution at which half of the panelists would detect the odor. For example, a D/T value of 100 means that the odorous air must be diluted 100 fold before 50% of the panel members would not detect the odor. A D/T value of 1 is defined as the detectable threshold or a point at which a person with average sensitivity detects the presence of an odor in an otherwise clean environment. The D/T is synonymous with ED_{50} and the term "odor unit." In other words, an odor unit of 1 represents the median detectable threshold level. Odor levels less than 1 are below the median detectable threshold level. Odor levels less than 0.1 odor units are below <u>any</u> detectable level.

Odor concentration determinations were conducted in accordance with ASTM Standard of Practice E679.91, Determination of Odor and Taste Thresholds by a Forced-Choice Ascending Concentration Series of Limits.

3.3.2.2 - Odor Intensity

Butanol intensity measurements were also performed to characterize the intensity of the odor samples. Odor threshold alone does not provide an indication of intensity at varying dilutions. Butanol intensity values provide a comparison of the strength of a specific odor to the strength of the odor emitted from butanol alcohol at various concentrations.

Odorants are typically found to change in intensity according to the power relationship, Intensity (S) = KC^n where K and n are coefficients dependent on the odorant and C, the concentration. For butanol, the value for n is 0.66. By defining an odor intensity of 250 parts per million of butanol as 10, an odor intensity scale can be developed where K = 0.261. This reference scale is used to define the intensity of odors.

A dynamic-dilution binary scale olfactometer was used to determine the characteristic of butanol intensity. This device has eight (8) glass sniffing ports attached to a free spinning wheel. Each port was supplied with a successively higher concentration of butanol to establish a range of odor intensities for comparison with odor samples. Panelists were asked to judge the intensity of an undiluted odor sample with the butanol wheel to determine which dilution was most similar to the actual sample. Responses from each panelist were recorded and used to calculate the equivalent butanol intensity value. Odors with the butanol intensity value less than 1.0 ppm are generally considered weak and approach threshold intensity. The actual threshold for butanol is 0.3 ppm.

3.3.2.3 - Odor Persistence

Persistency is a term used to indicate the pervasity of "lingering" impact of an odor in the atmosphere. Determination of persistency is based on a comparison of the odor at various dilutions with intensity at those dilutions. The perceived intensity of an odor will change in relation to its concentration. However, the rate of change in intensity versus concentration is not the same for all odors. This rate of change of intensity is termed the "persistency" of the odor. More persistent odors have a higher perceived intensity at lower concentrations; therefore they appear to "hang around" longer than less persistent odors.

The persistency of an odor is represented as a "dose-response" function that is determined from intensity measurements of an odor at full strength and at other dilutions above the threshold level. The plotted values, as logarithms, of the intensity and dilution ratio establish the dose - response function. The slope defines the persistency.

3.4 - Odor Sampling Results

3.4.1 – 2001-02 Investigation

Table 3.2 presents the primary data concluded by the odor panels as well as the data collected in the field during the sampling. The table only includes the D/T value for each sample. For a more detailed data presentation, refer to the appendix of this report.

In all cases, the data regression was excellent. In some cases, the regression becomes difficult since as the D/T and the intensity of odors become low, it is sometimes difficult to differentiate the odor level at varying dilutions.

Further interpretation and discussion of the data will be provided in Section 4 of this report.

3.4.2 – 2000/2001-02 Data Comparison

Table 3.3 compares the minimal collected during the preliminary 2000 investigation with that collected in 2001-02. During the 2000 investigation, the biological system was being operated in an anoxic/aerobic mode. As can be seen, the data was much higher in 2000 compared with that in 2001-02. Although there is no firm information to explain the differences in the data, the following are possible reasons for the difference:

- The data for the North scrubbers, the Central pumping station and the primary clarifier quiescent area indicates a high concentration of odor entering the facility at that time. Data collected by Metro staff would corroborate the fact that the concentration of hydrogen sulfide

Table 3.2
Base Analytical Results (2001-02 Investigation)
Central WWTP

Location	Sample #	D/T	H_2S (ppm(v))
N. Scrubber System #1 Exhaust	3	392	60
N. Scrubber System #2 Exhaust	6	961	100
N. Scrubber System #3 Exhaust	8	200	0.5
N. Scrubber System #4 Exhaust	10	1146	55
S. Scrubber System #1 Exhaust	34	30	0.007
S. Scrubber System #2 Exhaust	31	6	0.006
Central Scrubber System Exhaust	52	241	0.00
Old Grit Channel	44	732	1.2
N. Primary Influent Channel	11	737	6.5
N. Primary Clarifier	12	133	0.33
S. Primary Clarifier	13	284	0.013
N. Primary Effluent Channel	14	282	48
Screw Pumps	15 16	247 243	0.083 0.06
Aeration Influent Channel	68	282	48
Aeration Basin Influent – Aerobic Aeration Basin Influent – Anoxic	17 20	6 24	0.005 1.1
Aeration Basin – Anoxic	21	100	2.2
Aeration Basin – Midpoint – Aerobic Aeration Basin – Midpoint – Anoxic	18 23	8 34	0.007 0.024
Aeration Basin – End – Aerobic Aeration Basin – End – Anoxic	19 24	8 17	0.01 0.011
Mixed Liquor Channel	25	23	0.004
Final Clarifier	39	14	0.004
Thickener Wet Well	40	153	0.04
Thickener Bldg Exhaust	41	6	0.059
Solids Wet Well	47	732	13.0
Dewatering Building w/ Permanganate Addition	43 45	523 325	30.0 4.8
Dewatering Building w/o Permanganate Addition	42 46	111 84	32.0 24.0
Old Solids Dewatering Bldg. Fan	54 55	211 486	35 -
Dewatered Sludge	48	458	0.27
Centrate Channel	56	167	0.0

varies significantly. If high odor concentrations are entering the facility, those concentrations will tend to carry into and through the primary treatment processes.

- During the time of the first sampling, it was clear that the north scrubbers were removing very little odor from the screening and grit processes. This is an additional reason for the high odor level out of the north scrubbers.
- During the first sampling period, the biological system was being operated in an anoxic/aerobic mode, whereas, it is believed that during the second sampling, that complete anoxic conditions were not occurring within the anoxic basins. This could explain the difference in the aeration data.

The solids will become more odorous is the material has been subjected to anoxic or anaerobic conditions. It is believed that this was the case during the first sampling period, and would explain the higher D/T recorded for the dewatering building exhaust in 2000.

Table 3.3
Comparison of 2000 vs 2001-02 Data
Central WWTP

Location	D/T	
	2000	**2001-02**
N. Scrubber System Exhaust	11,010	200 – 1146
Central Pumping System Exhaust	150	241
Primary Clarifier – Quiescent Area	2,047	133
Aeration Basin – Anoxic Zone	3,727	100
Aeration Basin – Aerobic Zone	97	33
Dewatering Bldg. Exhaust	4,773	84 – 486

4.1 - Odor Emission Rates

Sensory data alone cannot be used to conclude whether a specific odor source can become an odor problem. Although a specific release point may have a high odor concentration and/or intensity, if that source has a low air release rate, it may not be a problem. The air release rate for area sources will depend on the surface area of the particular unit process. The air release rate for point sources will be the actual airflow rate being discharged. The air release rate for area sources with air addition will be dependent on both the air flow rate and the surface area.

Sensory data coupled with calculations of volumetric emission rates were used to estimate the mass of odor emissions in terms of odor concentration and intensity. Point source odor emission rates were quantified by multiplying both odor concentrations (D/T) and equivalent butanol intensity concentrations by the estimated volumetric rate of the exhaust stream. Area source odor emission rates were determined from estimates of odor release per unit area multiplied by the total surface area of each source, multiplied by the odor concentration and/or equivalent intensity. The estimated release rate for quiescent sources was calculated assuming a PAN evaporation rate at a temperature of 90o F. For turbulent sources such as splitter boxes and weirs, turbulence factors were used. The exhaust rate for area sources with air addition was the air rate being introduced into the process.

Mass emissions from the various sources identified at the WWTP were used as the basis for evaluation of atmospheric dispersion and impact on the surrounding areas.

Table 4.1 tabulates the exhaust and odor emission rates calculated for all unit processes that were sampled. The odor emission rate (OER) is based on the D/T of the sample and the exhaust rate. The OER is, therefore, the product of the D/T times the exhaust rate reported in D/T – CFM x 10^6.

4.2 - Screening of Odor Emissions

Table 4.2 ranks the sources based on D/T and odor emission rates.

4.3 - Meteorological Factors

The most significant factors in air transport are the local meteorological conditions. Such local weather conditions play a key role in the overall impact of odor emissions on the area surrounding the source. The most significant factors governing odor dispersion are:

- Atmospheric stability
- Wind speed, and
- Wind direction

Table 4.1
Odor Exhaust Rates and Emission Rates
Central WWTP

Location	Sample #	Exhaust Rate Ft^3/Min	Odor Emission Rate $D/T \times ft^3/min \times 10^6$
N. Scrubber System #1 Exhaust	3	8,000	3.14
N. Scrubber System #2 Exhaust	6	8,000	7.69
N. Scrubber System #3 Exhaust	8	8,800	1.76
N. Scrubber System #4 Exhaust	10	2,000	2.29
Total North Scrubber Systems	-	26,800	14.88
S. Scrubber System #1 Exhaust	34	12,000	0.36
S. Scrubber System #2 Exhaust	31	10,800	0.072
Total South Scrubber Systems	-	22,800	0.43
Central Scrubber System Exhaust	52	12,000	2.89
Old Grit Channel	44	170	0.12
N. Primary Influent Channel	11	500	0.37
N. Primary Clarifier	12	2,067	0.27
N. Primary Clarifier Weir	-	1,033	0.41
N. Primary Effluent Channel	14	4,945	1.39
Total North Primary Clarifiers		23,667	2.45
S. Primary Clarifier	13	5,167	1.47
Screw Pumps	15	1,020	0.25
	16	1,020	0.25
Total Screw Pump	-	2,040	0.5
Aeration Influent Channel	68	3,252	0.92
Aeration Basin Influent – Aerobic	17	3,333	0.02
Aeration Basin Influent – Anoxic	20	1,750	0.04
Aeration Basin – Anoxic	21	1,750	0.18
Aeration Basin – Midpoint – Aerobic	18	3,333	0.03
Aeration Basin – Midpoint – Anoxic	23	3,333	0.21
Aeration Basin – End – Aerobic	19	3,333	0.03
Aeration Basin – End – Anoxic	24	3,333	0.06
Mixed Liquor Channel	25	1,600	0.02
Total Aeration – Aerobic	-	49,278	1.01
Total Aeration – Anoxic	-	49,278	1.45
Final Clarifier	39	8,388	0.12
Thickener Wet Well	40	26	0.01
Thickener Bldg Exhaust	41	5,000	0.03
Solids Wet Well	47	15	0.01
Dewatering Building w/ Permanganate Addition	43	9,900	5.18
	45	9,900	3.12
Dewatering Building w/o Permanganate Addition	42	9,900	1.10
	46	9,900	0.83
Old Solids Dewatering Bldg. Fan	54	20,500	4.33
	55	20,500	4.81
Total Dewatering Bldgs.	-	157,699	85.35
Dewatered Sludge	48	99	0.05
Centrate Channel	56	284	0.05

Table 4.2
Source Ranking (Descending Order)
Central WWTP

D/T	OER
N. Scrubber #4 Exhaust	Total Dewatering Bldgs.
N. Scrubber #2 Exhaust	Total N. Scrubbers
N. Primary Influent Channel	N. Scrubber #2 Exhaust
Old Grit Channel	Auxiliary Solids Bldg.
Solids Wet Well	Old Solids Bldg.
Total North Scrubbers	N. Scrubber #1 Exhaust
Auxiliary Solids Bldg.	Central Scrubber Exhaust
Old Solids Bldg.	Total Primary Clarifiers
Dewatered Solids	N. Primary Scrubber #4 Exhaust
Total Screw Pumps	N. Primary Scrubber #3 Exhaust
Primary Clarifier Weirs	S. Primary Clarifiers
Total Dewatering Bldgs.	Total Aeration – Anoxic
N. Scrubber #1 Exhaust	N. Primary Effluent Channel
Total Aeration – Anoxic	Total Aeration – Aerobic
S. Primary Clarifier	Aeration Influent Channel
N. Primary Effluent Channel	Total Screw Pumps
Aeration Influent Channel	Primary Clarifiers Weir Area
N. Screw Pump	N. Primary Influent Channel
Total Aeration – Aerobic	N. Scrubber #1 Exhaust
S. Screw Pump	N. Primary Clarifiers
Central Scrubber System Exhaust	N. Screw Pumps
N. Scrubber #3 Exhaust	S. Screw Pumps
Centrate Channel	Aeration Basin Anoxic Zone
Total N. Primary Clarifiers	Old Grit Channel
Thickener Wet Well	N. Final Clarifiers
N. Primary Clarifiers	Aeration Basin Midpoint – Anoxic
Aeration Basin – Anoxic	Aeration Basin 1st Aerobic – Anoxic
Aeration Basin Midpoint – Anoxic	N. Scrubber #4 Exhaust
Aeration Basin – 1st Aerobic – Anoxic	S. Scrubber #2 Exhaust
S. Scrubber #1 Exhaust	Aeration Basin Effluent – Anoxic
Aeration Basin Influent – Anoxic	Centrate Channel
N. Mixed Liquor Channel	Dewatered Solids
Aeration Basin Effluent – Anoxic	Aeration Basin Influent – Anoxic
Final Clarifier	Mixed Liquor Channel
Aeration Basin Midpoint – Aerobic	Thickener Bldg. Exhaust
Aeration Basin Effluent – Aerobic	Aeration Basin Midpoint – Aerobic
Aeration Basin Influent – Aerobic	Aeration Basin Effluent – Aerobic
S. Scrubber System #2 Exhaust	Aeration Basin Influent – Aerobic
Thickener Bldg. Exhaust	Solids Wet Well

4.3.1 - Atmospheric Stability

Atmospheric stability refers to the degree of vertical turbulence present. The greater the turbulence, the greater the dispersion. Unstable air provides more turbulence, whereas stable air provides less turbulence. As would be expected, odor will travel greater distances during stable air conditions (least amount of turbulence). Therefore, the worst case for odor transport, when considering stability, will be during very stable air conditions.

Atmospheric stability is ranked in six categories, A through F or 1 through 6 depending on the reference. Stability Class A (or Class 1) refers to the most unstable air, and therefore, the most turbulent conditions were occurring at the time. Stability Class F (or Class 6) refers to the most stable condition. Therefore, for odor transport, Class F would provide the worst-case condition.

4.3.2 - Wind Speed

Wind speed also determines the rate of dilution, with higher wind speeds creating more dispersion and dilution than lower wind speeds. Wind speed can be routinely measured as low as one meter per second. The condition, when the wind speed is less than one meter per second, is considered “calm”. For reference purposes, 1 meter per second is approximately equivalent to 2.23 miles per hour.

When combining the impacts of atmospheric stability with wind speed, the worst case for odor transport is during Class F stability and a wind speed of 1 meter per second.

4.3.3 - Wind Direction

Wind direction determines the direction in which the odorous air will travel. For the initial modeling, wind direction was not considered. Therefore, all results will be considered radial results and not specific to any one wind direction.

4.4 - Dispersion Modeling

Odor impacts on neighboring areas surrounding the WWTP were evaluated by estimating ground level odor concentrations radially around the WWTP. In order to determine the odor concentrations, atmospheric dispersion modeling of odor emissions was performed using the USEPA Screen Model, Version 3.0. This model is based on a standard gaussian model that predicts average atmospheric concentrations at downwind receptors for a minimum time of one hour. The model provides a good indication of average short-term conditions, but does not predict the peak instantaneous occurrences of odor above threshold that can occur even when the mean value for an hour is below the threshold limit. It is known that peak or instantaneous concentrations of odor can occur in “puffs.” The paragraphs that follow will indicate how this problem was managed.

1. Develop Dose - Response Slope - A dose response relationship was developed for each source. The

logarithm of the butanol intensity (y-axis) was plotted against the logarithm of the odor concentration (D/T) (x-axis).

2. Select End Point Concentration - Based on the assumptions indicated below, the end point concentration in micrograms per cubic meter was determined from the dose-response curve.

3. Screen Model - The source concentration (grams per second) was input into the model along with all other data. Modeling was performed to determine the distance from the source, at various atmospheric stabilities and wind speeds, before reaching the allowable downwind concentration. All distances less than 100 meters were disregarded during this initial modeling.

The following assumptions were used to determine end point concentrations:

1. Average Conditions (Hourly) - For hourly conditions, the actual concentration found in the odor survey was used as the initial concentration. The end point concentration was determined to be that concentration associated with a D/T of 1, corrected based on the slope of the dose – response curve. This was selected as a conservative estimate for screening purposes.

2. Peak (Instantaneous) - For peak conditions, the actual concentration found during the odor survey was multiplied by a factor. The point source factor was 3 and the area source factor was 10. These values were selected based on previous plume dispersion studies. An end point of 1 was also assumed for screening purposed.

The wind speed considered during the modeling was one meter per second (worst case).

The input data for the modeling is included in the appendices of this report.

4.5 - Results of Odor Modeling

Table 4.3 presents the results of the odor modeling under both hourly and peak conditions at an F stability class and a wind speed of 1 meter/second. The remaining modeling results can be found in the appendices of this report.

For the north scrubbers, the north primary clarifiers, the screw pumps, the aeration basins and the various dewatering buildings the odor emission rates were totaled, i.e. “Total Primary Clarifiers”, etc. and inputted into the model.

All distances are in meters. No distances greater than 2,000 meters were modeled.

Odors that transport significant distances are termed Class 1 sources (odors). They are indicated in Table 4.3.

Table 4.3
Class 1 Odor Sources
Central Creek WWTP

Source	Average Transport Distance (Meters)	Peak Transport Distance (Meters)
Total Dewatering Bldgs	>2,000	>2,000
Total North Scrubbers	>2,000	>2,000
N. Primary Clarifiers	810	>2,000
N. Primary Effluent Channel	810	>2,000
S. Primary Clarifiers	550	1,610
1^{st} Third Primary Effluent Channel	360	1,610
Old Grit Channel	280	510
N. Primary Clarifier Weir Area	190	380
Total Aeration – Anoxic	180	340
Aeration Influent Channel	170	350
Total Aeration – Aerobic	80	1,110
2^{nd} Portion of Primary Effluent Channel	150	1,210
N. Primary Influent Channel	-	1,190
Screw Pumps	-	1,100
N. Primary Quiescent Area	-	800

The above table also indicates the sensitivity of the data with regards to peaking factors. In some cases the transport distance under average conditions is considerably less than for peak conditions. This is especially true for the total aeration (aerobic conditions), the 2^{nd} portion of the primary effluent channel, the screw pumps and the north primary clarifier quiescent area. Although the transport distance for these sources may be low during average conditions, the distance during peak conditions remains high. Therefore, these sources should also be considered significant odor sources.

4.6 - Calm Wind Conditions

The results presented in the previous section are for conditions when mixing occurs and exclude calm wind conditions (wind speed < 1 meter/sec.). These conditions historically occur in the Nashville less than 10% of the annual hours. Calm wind conditions present the following significant problems:

- During a period of calm wind conditions, odors tend to concentrate in the atmosphere above the source and will move away from the source with no dispersion. Should the concentrated odors move in the vicinity of a receptor, the intensity could be considerably greater than what is predicted by the model
- During calm wind conditions, the concentrated odor cloud becomes the theoretical source of emissions. Since the concentrated

odor cloud can move away from the source, once dispersion begins, the distance from the actual source to the receptor can be decreased from that predicted in the model.

Those sources that would be of concern during calm wind conditions are those with significant odor emission rate (> .5 cfm X 10^6 odor units) and sources with high D/T values. The actual D/T value is subjective, but most would select 100. Calm wind problems occur most often with area type sources. Dispersion from fan discharges, assuming the discharge velocity is sufficiently high, creates self-induced dispersion.

- In addition to the Class 1 sources indicated above, the exhaust from the Central pumping station becomes a problem during calm conditions. In addition, specific areas of the aeration basins also become significant.

The Class 1 sources and the additional sources comprise the list for Class 2 odor sources.

4.7 – Odor Logs

Odor logs were maintained by some citizens who live in the area of the treatment plant. The data from the odor logs was analyzed by a computer program that uses triangulation to identify the potential source for each odor occurrence recorded. However, there was not sufficient data to adequately triangulate the events with the specific sources (see Appendix).

The majority of event, however, occurred during “calm air” conditions.

4.8 - Summary and Discussion

4.8.1 – Priority Odor Sources

Sources that are considered problems during low wind conditions are termed “Class 1” sources. Odor sources that are considered problems during calm wind conditions are termed “Class 2” sources. Table 4.4 summarizes both source classes.

4.8.2 – Discussion

The following is a discussion of each of the priority odor sources. This discussion is focused on the data and the interpretation of the data.

Table 4.5 presents the relative priority of all significant odor sources based on odor emission rate.

Table 4.4
Priority Odor Sources (In order of Priority based on Transport Distance)
Central WWTP

Class 1 Sources	Class 2 Sources
Total Dewatering Bldgs.	Class 1 Sources
Total North Scrubber Exhausts	Various Individual Portions of the Aeration System during both anoxic and aerobic modes of operation
Total North Clarifiers	Central Pumping Station
N. Primary Effluent Channel	
Aeration Basins – Anoxic Mode	
South Primary Clarifiers	
1st Third of Primary Effluent Channel	
2nd Portion of Primary Effluent Channel	
Aeration Influent Channel	
N. Primary Influent Channel	
North Primary Clarifier Weir Area	
Screw Pumps	
Primary Clarifier Quiescent Area	
Old Grit Channel	
Aeration Basins – Aerobic Mode	

Table 4.5
Composite Odor Profile
Central WWTP

Source	Odor Emission Rate	% of Total
Total Dewatering Bldgs.	147.18	87.1
Total North Scrubber Exhausts	14.88	8.8
Central Pumping Station	2.89	1.7
Total North Clarifiers	1.75	1.0
Aeration Basins – Anoxic Mode	0.99	0.6
South Primary Clarifiers	0.73	0.4
Screw Pumps	0.5	0.3
Old Grit Channel	0.1	0.1

As can be seen from the above table the most significant odor source, based on odor emission rates, is that from the dewatering buildings followed by the existing north grit scrubbers.

The percent of odor contribution should not be confused with the priority of odor sources based on dispersion and transport distances. As can be seen from the above table, although the source may contribute odor, due to the proximity to the property boundaries, and / or the exit velocity from the process, the source may or may not be impacting the neighboring areas.

4.8.2.1 – Influent Wastewater Characteristics

Hydrogen sulfide (gas) measurements have been taken on the influent to the north grit chambers. Concentrations exceeding 200 ppm(v) have been measured. It would appear that this is due to the intermittent pumping of the wastewater to this unit process. The Brown's Creek pumping station has two parallel force mains which discharge to Central WWTP. These force mains operate one at a time except during periods of high flows due to rainfall events. When a force main is out of service, the sewage sits in the pipe and H_2S is formed due to the low dissolved oxygen conditions. When the force main is placed back in service, the H_2S is released at the north grit chambers, resulting in H_2S spikes. The Water Services staff has attempted to control the problem by alternating the force mains more often, with mixed results. Although control at the north grit chambers will be required regardless of the concentration, the peak concentrations of hydrogen sulfide could create significant corrosion problems. The scrubbers associated with the north grit chambers would operate more consistently if the concentration of hydrogen sulfide were more equalized.

4.8.2.2 – North Scrubber Systems

Table 4.6 provides the efficiencies calculated during the investigation:

Based on the data, the scrubbers are providing little treatment. The data would also indicate that the D/T actually increases through the scrubber systems. Most probably, this is due to incomplete oxidation within the scrubbers resulting in chlorinated byproducts being exhausted to the atmosphere.

Attempts have been made to optimize the scrubbers by ensuring consistent pH control. Although the attempts have shown some success, the data has been somewhat inconsistent and the labor required to maintain optimization has been excessive.

Table 4.6
North Scrubber Efficiencies
Central WWTP

Scrubber/Stage	Inlet D/T	Outlet D/T	% Removal
Scrubber #1 Inlet - 2nd Stage	130	166	0
Scrubber #1 2nd Stage - Exhaust	166	392	0
Scrubber #2 Inlet – 2nd Stage	327	425	0
Scrubber #2 2nd Stage – Exhaust	425	961	0
Scrubber #3 Inlet – Exhaust	182	200	0
Scrubber #4 Inlet – Exhaust	185	1146	0

4.8.2.3 – Central Pumping Station Scrubbing Systems

The Central Pumping Station scrubbing system exhaust becomes a significant source only during calm air conditions even though the efficiency of the scrubber found during the investigation was 0%. The primary reason that this is not a class 1 source is the assumed dispersion that occurs from the fan discharge.

It should also be mentioned that only one scrubber was operating during the period of the investigation due to fire damage. Based on a plume analysis, if a second scrubber was operating, the odors would be additive. Therefore, this area could become a significant source.

4.8.2.4 – North Primary Clarifiers

The components of the total primary clarifiers and the associated odor emission rates are provided in Table 4.7.

Table 4.8 provides the transport distances of each of the individual components of the total primary clarifier area. As previously, the transport distances are based on a stability class of F and a wind speed of 1 meter/second.

This analysis would indicate that the quiescent area is not a significant problem source during average meteorological conditions. It is a significant source when considering

Table 4.7
North Primary Clarifiers
Central WWTP

Specific Unit Source	Odor Emission Rate	% of Total
Primary Influent Channel	0.37	15.2
Primary Clarifier – Quiescent	0.28	11.5
Primary Clarifier – Weir	0.4	16.4
Primary Effluent Channel	1.39	57.0

Table 4.8
Transport Distances of North Primary Clarifier Units
Central WWTP

Specific Source – Primary Clarifiers	Avg. Transport Distance (m)	Peak Transport Distance (m)
Primary Influent Channel	250	1,190
Primary Clarifier – Quiescent	-	800
Primary Clarifier – Weir	190	1,120
Primary Effluent Channel	810	>2,000

peaking and calm conditions. It should be remembered that the 2000 data indicated a D/T much higher than that found in 2001. Comparison of the 2001 data with library data would suggest that the 2001 data is lower than expected.

Table 5.8 also suggests that the primary effluent channel is the most significant source related to the North primary clarifiers. The channel can be segregated into two areas: (1) the 1st portion which is approximately 1/3 of the total area and which has significant turbulence, and; (2) the second portion which has very little turbulence. Table 4.9 provides the odor emission rates and the transport distances for the two areas.

4.8.2.5 – South Primary Clarifiers

The data used for the south clarifiers was based on half of the south primaries being in use. Normal operating procedure is to operate the south primary clarifiers only during "wet weather" events. Therefore, odors from this source will be minimized due to the fact that these clarifiers will not be used consistently.

The south transfer channel was not included in the area calculations for the south clarifiers.

4.8.2.6 – Screw Pumps

The screw pumps are a significant odor source under both dispersion and calm wind conditions.

4.8.2.7 – Aeration Basins

Table 4.10 provides the various transport distances of each unit component of the aeration system. The table will provide the data for the aeration basins operated in both the aerobic and anoxic modes.

Table 4.9
Primary Clarifier Effluent Channel
Central WWTP

Area	OER	% of Total	Transport Distance (Feet)	
			Average	**Peak**
1st Portion	**0.7**	**60**	**360**	**570**
2nd Portion	**0.47**	**40**	**-**	**370**

Table 4.10
Aeration Basin Transport Distances
Central WWTP

Specific Source – Aeration Basins	Avg. Transport Distance (m)	Peak Transport Distance (m)
Aeration Influent Channel	390	550
Aeration Basin Influent – Aerobic	-	510
Aeration Basin Midpoint – Aerobic	-	60
Aeration Basin Effluent – Aerobic	-	60
Aeration Basin Influent – Anoxic	-	80
Aeration Basin Anoxic – Anoxic	80	550
Aeration Basin 1st Aerobic + Mid – Anoxic	90	600
Aeration Basin Effluent – Anoxic	50	150

The data for the anoxic mode of operation is much lower than expected. As indicated earlier, the apparent reason for this low data is the fact that the facility was not in a completely anoxic mode. Therefore, Table 4.10 does not represent the transport distance actually expected if the aeration basins were operated in an anoxic mode.

4.8.2.8 – Dewatering Buildings

One of the most significant sources of odors is from the existing dewatering buildings. There is no attempt in this analysis to determine which building or which area of the buildings is contributing the most odors.

Neither of the dewatering buildings is currently equipped with odor control. Both of the buildings have had belt presses installed in buildings that were not designed to house belt presses. This has created ventilation problems and has likely compounded the odor problems inside the building.

Section 5
Requirements for Odor Abatement

5.1 - Abatement Objective

At the present time, there are no federal and/or state requirements or standards for odor control. When Congress and EPA addressed the most recent Clean Air Act Amendments, they had difficulty in determining specific requirements due to the site specific and area specific nature of odors. For this reason, they deferred the problem to states and local governments. Tennessee presently has no standards for odors. Many local governments, including Metropolitan Nashville, have nuisance ordinances that include odors. However, these standards are usually in narrative form rather than numerical. The purpose of most ordinances is to allow third party litigation against an odor producer and not necessarily, provide a clear standard for abatement.

Objectives for solving odor problems can and have been established based on different criteria:

- Economics - Some communities, when having an odor problem, allocate a certain amount of financial resources to a project, prior to understanding the actual cost for abatement. Odor reducing steps are implemented with the hope that the odor will be reduced.
- Frequency of Occurrence at a Specific Receptor - Another method of establishing an objective for odor abatement is to set an agreed upon frequency of odor occurrences at a specific location. This allows for odors to occur, but defines the frequency of occurrence.
- Source Odor Units - A specific standard at the source can be set. The standard would be in terms of a D/T.
- Property Line D/T - This method sets a specific standard at the property line of the facility. During agreed upon weather conditions, this standard is not to be exceeded.

Many municipal and county governments in the United States are establishing specific standards for odor concentration at property lines. Should the State of Tennessee and/or local government establish a standard in the future, it probably will be consistent with what is now occurring at other locations - a property line or boundary standard.

The actual numerical standard varies among localities. The range across the United States appears to be 2 - 15 odor units at the property line.

In the Southeast, a D/T of 5 (average conditions) is becoming prevalent. This objective allows for odors to occasionally cross the property boundary, but only during the most stable meteorological condition. Unless the specific unit process is very close to the property boundary, odors would not be witnessed outside of the property boundary during normal meteorological periods.

Metro Water Services established the following objective: a D/T of 5 (average condition) at the property boundary during dispersion conditions. Therefore, during some periods of time, odors will still be witnessed outside of the property boundaries. However, the frequency of these events will be greatly reduced.

For those unit processes very close to the property boundary, a more stringent objective should be considered. Based on the sensitivity analysis performed, an objective of 1 (peaking conditions) is recommended.

5.2 – Abatement Strategy

Care should be taken when interpreting Table 4.5, which shows the composite odor profile for the Central WWTP. Odors are not necessarily additive. Odors from different sources are only additive if they result from the same odorant and exist in the same dispersion plume. This is rarely the case with odors from different unit processes at waste treatment facilities. However, for sources such as the north scrubbers, dewatering buildings, primary clarifiers and aeration basins, odor from the individual components will combine.

If a less significant odor is addressed before a more significant one, the more significant odor will prevail and the receptor will notice little or no improvement in air quality. Therefore, it is essential to abate the odor source that transports the farthest first, and then abate the lesser sources second.

For the Central WWTP, the majority of odor events have been occurring from the dewatering buildings, north grit scrubbers, the primary clarifiers, the primary influent and effluent channels, and the aeration basins. Therefore, the abatement strategy must be to abate these odors prior to others.

5.3 - Required Percent Removals

Table 5.1 presents the required removal percentages for the problem odor sources. The percent removal is based on the distance to the closest property boundary. Removal efficiencies for a D/T of both 5 and 1 will be shown for average conditions and a D/T of 1 for peak conditions.

Since odor abatement for the dewatering buildings will be addressed in the biosolids project, no percent removal efficiencies have been calculated for those structures.

Table 5.1
Required Percent Removals for Significant Odor Sources
Central WWTP

Source	Distance to Property Boundary (Feet)	% Removal Required – Average Conditions		% Removal Required – Peak Conditions
		D/T = 5	D/T = 1	D/T = 1
North Scrubbers	80	70	90	98
Total Primary Clarifiers	120	0	70	95
North Primary Effluent Channel	120	0	67	96
Total Aeration – Anoxic	200	0	64	95
S. Primary Clarifiers	120	0	61	86
1st Third Primary Effluent Channel	150	0	59	95
Total Aeration – Aerobic	100	0	75	81
Total Screw Pumps	80	0	0	69
2nd Portion of Primary Effluent Channel	60	0	0	84
Aeration Influent Channel	150	0	85	96
Primary Clarifier – Weir Area	80	0	68	92
N. Primary Clarifier Influent Channel	120	0	0	94
N. Primary Clarifier Quiescent Area	80	0	0	76
Old Grit Channel	120	0	49	81

As can be seen from the above table, there is a significant difference in the removal efficiencies for meeting an objective of 5 at the property line versus meeting an objective of 1. It is recommended that a peak condition be considered for the following unit processes due to their proximity to the property boundary:

- North scrubbers
- North influent channel
- North primary clarifiers
- North primary effluent channel
- Screw pumps

For other areas indicating that no removal will be required for average conditions, calm air excursions should also be considered.

5.4 – Impact of Future Projects

As indicated in previous sections of this report, the exhaust from the dewatering buildings is one of the primary sources of odors into the surrounding neighborhoods. It is understood that a new dewatering facility will be constructed and the existing structures will be abandoned. The project will include digestion of the solids prior to dewatering and the use of centrifuges rather than the present belt presses. This change will have a significant benefit on odor reduction. The digested solids will have significantly less odor than undigested solids. In addition, centrifugation is principally an enclosed process and therefore, the exhausts to the atmosphere will be reduced.

Although odor control will still be required, the extent of the control will be much less than if an attempt was made at the present time to control odors from the existing structures.

5.5 – Alternatives for Abatement

The essential elements of successful odor control are:

- Adequate capture
- Adequate treatment
- Adequate dispersion

The last element is only important for stack design, which is associated with scrubbers.

5.5.1 - Technologies

5.5.1.1 – Change in Process

The modification or alteration of the unit process creating the odor is sometimes over-looked as an odor abatement strategy is. Many times an operational modification will not change the design intent of the process, but will reduce the odor emissions. Examples of process changes include changing aeration rates or taking basins out of service.

5.5.1.2 – Chemical Addition

Chemical addition is used predominantly to control sulfides and other reduced sulfur compounds in sewer systems. Typically, these chemicals are cation salts. Other chemicals are available for treatment facilities including enzymes and bacterial compounds that will attack odors other than those created from sulfides. Chemical addition for odor control is sometimes effective when the chemical can be added to the wastewater directly to stop or inhibit the formation of odor causing compounds. Some chemicals have been formulated for addition to the air. In order for these to be effective, contact between the chemical and the air-borne constituent must occur. For this reason, the surface area of the treatment unit emitting the odor must be small in order to ensure complete contact with odorous off-gas. In general, these types of products are usually most effective when the required percent removals are less than 75%. In addition, the products are effective when the odors are caused by unusual influent wastewater characteristics. As indicated previously, the influent characteristics at Central WWTP do not appear to be unusual.

5.5.1.3 – Structural Solutions

Structural solutions consist of covering and foul air treatment. These types of solutions are used when a high percent removal is required.

5.5.1.4 - Covers

Various types of covers are used:

- Enclosures – Sometimes it is advantageous to enclose the unit process in some type of building. This allows easy access to the process. The primary disadvantage is that, assuming that the space will be occupied, the minimum air change requirement is 12 air changes per hour. In some cases, in order to ensure worker's health and safety, greater air changes are required. This greatly increases the amount of air that must be treated.

- Area covers – Area covers only cover the area that allows odorous off-gas to escape. Covers can be manufactured from steel, aluminum, fabric, fiberglass and/or wood. The design of the cover will many times depend on the structural requirements. The primary disadvantage of covers is that they limit access to the basin.

5.5.1.5 Treatment Systems

Several types of treatment systems can be used for odor control. The primary types include:

1. Scrubbers - Many types of scrubbers are available. They can be implemented individually or in combination. Typical installations include the following:

    - Packed Bed Wet Scrubbing – Scrubbers utilize a chemical reaction to remove odorous compounds. For sulfur related compounds, alkaline scrubbing can be employed. For nitrogen-based off-gases, acid scrubbing is employed. For alkaline scrubbing, the traditional chemicals are sodium hydroxide and sodium hypochlorite, although oxidants such as ozone and hydrogen peroxide can also be used.

      Packed bed scrubbers rely on recirculation to provide the retention time required for adequate gas – liquid transfer. The foul air flows upward through media. As the recirculated liquid comes in contact with the foul air, the contaminants in the air are transferred to the liquid. The spent liquid is then wasted.

    - Mist Scrubbers – Mist scrubbers also use a chemical reaction to remove odorous compounds. Presently the Metro Central WWTP has two mist scrubber systems:

        - North Scrubbers
        - Central Pumping Station

      The foul air flows upward through a large vessel. Chemicals are sprayed through nozzles from above to create a "mist" within the vessel. As the chemicals come in contact with the contaminants in the foul air, the contaminants are transferred to the liquid phase.

      Whereas the time for transfer in packed bed scrubbers relied on the recirculation rate, the contact time in mist scrubbers is much shorter due to no recirculation.

   Wet scrubbers can be installed in stages dependent on the percent removal required. The advantage of wet scrubbing is that the percent removals achieved can be very high. Another advantage is that wet scrubbing is a controlled process. The disadvantage is that the cost for chemicals can be high if the inlet concentrations are high. Wet scrubbers also require maintenance.

2. Bio-filtration – Bio-filtration uses a biological process to remove odorous compounds from the foul air. Two types of bio-filters can be used: (1) bed; and (2) tower. The maximum capacity of tower bio-filters is limited, whereas the bed type can be constructed as large as necessary, assuming that space is available. In the case of the Central WWTP, bed type filters would be required due the capacities required.

   Bio-filtration has the advantage of requiring little maintenance and having no chemical cost. Because odor reduction is accomplished through a biological process, conditions that promote the growth of odor-removing bacteria must be maintained. The bed material must be continually wetted and some source of trace nutrients must be available in order to achieve acceptable removal efficiencies.

   The bio-filter bed can be constructed of several different materials. Compost type material (organic media) is typically used, but inorganic and synthetic medias are also available. Inorganic media resembles lava rocks, and has the necessary trace nutrients embedded in the media. The inorganic media has several significant advantages. The minimum detention time required for synthetic media is 20 to 40 seconds, depending on loading, whereas organic media requires a one minute or greater residence time. The depth of inorganic media beds can be up to 5 feet deep, while organic beds are limited to 3 feet. Therefore, use of inorganic bio-filter media results in significantly smaller bio-filters, an important consideration when installing new odor control units at an existing wastewater treatment plant. Other advantages of inorganic media are much longer life (10 years compared to 3 years), a long media warranty (10 years) and the ability to regenerate the media rather than replace it. For this study, the use of inorganic media has been assumed due to the space constraints.

   One disadvantage of bio-filters, assuming a bed type is used, is the space that is required. A typical design will require 1 ft^2 for every 1 – 3 cfm of air. The area can become quite large when a high volume of air requires treatment. Another disadvantage is that due to the bed type construction, the bio-filter becomes an area odor source. Little dispersion exists over the surface of the bed; therefore the required percent removals from a bio-filter need to be greater than with wet scrubbing. Finally, due to the fact that it is not a controlled process, the removal data can be inconsistent. In some cases, the removals have been reported high, whereas in other cases, the removals have been poor.

3. Ionization – This process involves ionization of supply air to the room. The ionized oxygen molecules react with the odor causing compounds in the air to control the odors. The

process is primarily used in enclosed structures and installed on the ventilation system.

There is little data related to this process. However, where it has been applied, it has been thought to be somewhat successful.

4. Other treatment systems – Although not evaluated in this analysis due to their high capital and operating costs, carbon and fume incineration can be employed.

5.5.2 – Multiple Vs. Single Treatment Units

Another consideration is whether to install multiple treatment units at specific locations or whether to install foul air ducts to transport the foul air to a central location. The benefit of multiple units is the duplicity that is provided. The use of a single unit allows high odor sources to mix with lower sources, diluting the higher sources and reducing the overall odor removal requirements However, typically, this decision is determined by the relative economics of the various alternatives.

5.5.3 – Ventilation Requirements

The following should be considered when designing an adequate odor capture system:

1. For enclosed <u>occupied</u> structures, adequate ventilation should occur in order to conform to OSHA worker safety limitations. In addition, for areas that could be subject to explosion potential, a minimum air change is required. Also for enclosed structures, adequate face velocities at openings should be considered to minimize fugitive escape.

2. For structures with forced air addition, the exhaust rate must be at least equal to the amount of air addition. However, in addition, adequate sweep velocities should also be ensured.

3. For structures that are unoccupied and have no air addition, adequate sweep velocity (and/or face velocities) is the principle criterion.

5.6 - Abatement Alternatives

5.6.1 - General

As indicated above, various alternatives are available for odor control, the effectiveness of which is dependent on the percent removal required. The following general conclusions are offered:

1. <u>Process Change</u> – The following process changes should be considered:

   - Influent to the North Grit Area – A process change should be considered to dampen the peaks of hydrogen sulfide entering the north grit units. This could be accomplished by more frequent alternation of the force mains from the Brown’s Creek Pumping Station.

   - Aeration Basins - As will be noted in following paragraphs, there is no consideration at this time to treat odors from the aeration basins. Normally, the aerations basins are operated in the aerobic mode. Odor sampling indicates that operation in the aerobic mode does not result in transport of odors off-site. However, it is sometimes desirable to operate the aeration basins in anoxic mode in order to control nocardia foaming. If the biological system is operated in an anoxic mode, odors will transport off-site, and the odor objective of a D/T of 5 at the property line will not be achieved. Therefore, in order to control odors, careful control of the oxygen levels in the aeration basins is required to prevent formation of nocardia foam and eliminate the necessity of operating the aeration basins in the anoxic mode.

- South Primaries – The use of the South Primary Clarifiers should be limited as much as possible. If the use of these primaries can not be limited, odor control should be considered
- Old Grit Channel – No abatement for this process will be recommended. An evaluation for abandoning this tank should be performed. It may require bypassing the unit, however, due to the distance of this process from others that will be controlled, odor control will be costly.
- Aeration Influent Channel – No abatement will be recommended for this source at this time. However, it is recommend that the existing aeration in the channel be terminated. This will reduce the exhaust rate from the channel. However, additional solids deposition could also occur, increasing the concentration of odor. This change should be evaluated in the future.

2. <u>Housekeeping</u>
   - Aeration influent channels - During the inspection, it was noticed that a significant amount of debris was being collected in the channel. This creates additional odors that were not considered during this investigation. The channels should be cleaned on a regular basis.
   - Final clarifier scum – The original sampling occurred during a period when the biological system was operating properly. During a subsequent investigation, a significant amount of scum was noticed on the surface of the final clarifiers. This scum will also contribute odors and should be removed as soon as possible. In addition, control of foaming in the aeration basins will reduce scum formation on the clarifiers.
2. <u>Chemical Addition</u> – No recommendation for chemical addition is offered at this time.
3. <u>Structural Solutions</u> – Based on the required percent removals required structural odor control will be required for the:

Table 5.2
Recommended Capture Rates
Central WWTP

Location	Area (ft^2)	Air Volume (cfm)	Design Criteria	Capture Rate (cfm)
North Grit Area	-	-	-	27,000
Primary Influent Channel	2,498	-	1 cfm / ft2	2,498
Primary Clarifier Quiescent	41,334	-	.5 cfm / ft^2	20,667
Primary Clarifier Weirs	10,334	-	1 cfm / ft^2	10,334
North Primary Clarifiers	54,166	-	-	33,499
Transfer Channel	5,000	-	1 cfm / ft^2	5,000
1st Third Primary Effluent Channel	8,241	-	1cfm / ft^2	8,241
2nd Third of Primary Effluent Channel	16,482	-	.5 cfm / ft^2	8,241
Total Primary Effluent Channel	24,743	-	-	16,482
Screw Pumps	16,000	-	1 cfm / ft^2	16,000

- North grit area
- Primary clarifiers including the influent channel, primary clarifiers quiescent and weir areas and effluent channel.
- Screw pumps
- Transfer channel – This source was not sampled during the investigation. However, one mode of operation would be to send wastewater from the south grit area to the north. If this occurs, it can be expected that the odors from this source would be comparable to that from the primary influent channel.
- Dewatering buildings
- Aeration tanks, if process changes do not minimize the odor levels
- Old Grit Channel, if process cannot be abandoned.

As indicated previously, the central scrubber exhaust is a Class 2 odor source. The impact of this source in comparison with the Class 1 sources is minimal. Therefore, it is recommended that no additional control be considered at this time.

It is assumed that mist scrubber technology will not be evaluated due to their historical removal efficiency and cost of operation.

5.6.2 – Required Capture Rates

Prior to determining the available alternatives for odor control, the air volume for each odor source must be determined. The capture rates are based on the following:

1. Ensuring that the area is being controlled under negative pressure.
2. Ensuring adequate capture velocities at all openings such as doors and windows.
3. Ensuring the safety of the operating personnel.

Table 5.2 provides the recommended capture rates.

5.6.3 – Available Alternatives

The alternatives analysis will not include treatment of air from the south primary clarifiers or the aeration basins. The following alternatives will be considered:

1. Alternative 0 – Do nothing
2. Alternative 1 – Two stage packed bed scrubbing for treating air from the north grit area
3. Alternative 2 – Single stage packed bed caustic scrubber treating air from the north grit basins (18,000 cfm) followed by bio-filtration for the remaining portions of the north grit area and the uncovered portion of the primary influent channel
4. Alternative 3 – Single stage packed bed scrubbing to treat the air from the uncovered portion of the primary influent channel, the primary clarifier quiescent and weir areas and a portion of the primary effluent channel
5. Alternative 4 – Same as alternative 3, but use bio-filtration in lieu of packed bed scrubbing
6. Alternative 5 – Same as alternative 3, but add air from the north grit area.
7. Alternative 6 – Same as alternative 4, but add air from the north grit area
8. Alternative 7 – Single stage packed bed scrubber for treating the air from the screw pumps
9. Alternative 8 – Single stage packed bed scrubber for treating the air from the transfer channel
10. Alternative 9 – Single stage packed bed scrubber for treating the air from the screw pumps and transfer channel.
11. Alternative 10 – Same as alternative 9, but use bio-filtration in lieu of packed bed scrubbing
12. Alternative 11 – Bio-filtration for the north grit area, the primary influent channel, the primary clarifier quiescent and weir areas, the primary effluent channel, the screw pumps and the transfer channel.

5.6.3.1 – Discussion of Alternatives

Prior to providing capital and operating cost estimates for the above alternatives and combination of alternatives, some discussion is warranted.

<u>Do Nothing Alternative</u> – The do nothing alternative is not feasible. Complaints from the public and compliance with Metro Health Department requirements prompted this study, and some action is required to resolve these issues.

<u>Treatment for the North Grit Area</u> – Due to the high concentrations of hydrogen sulfide entering the north grit basins, if these unit processes are to be treated alone (without the addition of other foul air), bio-filtration cannot be used.

5.6.3.2 – Assumed Basis of Design

Tables 5.3 and 5.4 provide the recommended basis of design for the listed alternatives.

5.7 – Estimates of Costs

5.7.1 – Cover Costs

Table 5.5 presents the estimates for covering the various unit process considered in the above alternatives.

Table 5.3
Recommended Basis of Design
Packed Bed Wet Scrubbing
Central WWTP

Alternative	Air Flow (cfm)	Design H_2S (ppm(v))	Required % Removal	Tower Diameter (ft)	Stages	Packing Depth (ft)	Recirculation Rate (gpm)
Alt 1	27,000	100	80	8	2	10	326
Alt 2	18,000	148	90	7	1	8	250
Alt 3	42,000	8	90	11	1	10	510
Alt 5	69,000	45	90	2@10	1	10	510
Alt 7	16,000	30	90	6	1	10	185
Alt 8	5,000	5	90	4	1	10	82
Alt 9	21,000	24	90	7	1	10	250

Table 5.4
Recommended Basis of Design
Bio-filtration
Central WWTP

Alternative	Air Flow (cfm)	Design H_2S (ppm(v))	Required % Removal	Residence Time (sec)	Depth (ft)	Area (ft^2)
Alt 2	30,000	10	90	30	5	3,000
Alt 4	42,000	8	95	30	5	4,200
Alt 6	69,000	45	95	40	5	9,246
Alt 10	21,000	24	95	40	5	2,814
Alt 11	90,000	40	98	40	5	12,060

5.7.2 – Capital and Operating Costs

Tables 5.6 and 5.7 provide estimates for the capital and operating costs associated with the considered alternatives. The estimates assume the following:

- Electrical – 20% of control cost
- Site work – 20% of control + ducting costs
- Contingencies – 35%
- Engineering – 15%
- Labor for wet scrubbing - $1.00/cfm/year – Minimum of $20,000 per year
- Labor for bio-filtration - $20,000/year regardless of size
- Electrical - $.035 per kw/hr
- NaOH - $0.45/gallon
- NaOCl - $0.73/gallon
- Bio-filter media replacement - $24/ft^3 – 10 year life

Table 5.5
Cover Cost Estimates
Central WWTP

Alternative	Area (ft^2)	Unit Cost ($)	Total Cost ($)
Alt 1 and 2	-	-	0
Alt 3 and 4	62,400	35	2,184,000
Alt 5 and 6	62,400	35	2,184,000
Alt 7	16,000	60	960,000
Alt 8	5,000	35	175,000
Alt 9 and 10	21,000	35	735,000
Alt 11	83,400	-	2,919,000

Table 5.6
Capital Cost Estimates
Central Creek WWTP

Alt.	Demolition	Covers	Control	Ducting	Subtotal	Contingency	Eng.	Total
Alt 0	0	0	0	0	0	0	0	0
Alt 1	100,000	-	450,000	-	550,000	193,000	111,000	854,000
Alt 2	100,000	-	1,250,000[i]	-	1,350,000	473,000	273,000	2,096,000
Alt 3	-	2,184,000	625,000	637,000	3,446,000	1,206,000	698,000	5,350,000
Alt 4	-	2,184,000	1,260,000	637,000	4,081,000	1,428,000	826,000	6,335,000
Alt 5		2,184,000	1,100,000	893,000	4,177,000	1,462,000	846,000	6,485,000
Alt 6	-	2,184,000	2,070,000	893,000	5,147,000	1,802,000	1,042,000	7,991,000
Alt 7	-	960,000	300,000	364,000	1,624,000	568,000	329,000	2,524,000
Alt 8	-	175,000	120,000	228,000	523,000	183,000	106,000	812,000
Alt 9	-	735,000	400,000	652,000	1,787,000	625,000	362,000	2,774,000
Alt 10	-	735,000	756,000	652,000	2,143,000	750,000	434,000	3,327,000
Alt 11	100,000	2,919,000	2,340,000	2,340,000	7,599,000	2,660,000	1,539,000	11,798,000

[1] Includes $350,000 for packed bed scrubber and $900,000 for bio-filter

Table 5.7
Operating Cost Estimates
Central WWTP

Alternative	Labor[1]	Electrical	Chemicals	Media Replacement	Total
Alt 0	115,000	18,000	1,299,000	0	1,432,000
Alt 1	27,000	18,000	948,000	-	993,000
Alt 2	40,000	27,000	131,000	36,000	234,000
Alt 3	42,000	18,000	118,000	-	178,000
Alt 4	20,000	18,000	-	50,400	88,400
Alt 5	69,000	32,000	545,000	-	646,000
Alt 6	20,000	32,000	-	111,000	163,000
Alt 7	20,000	17,000	169,000	-	206,000
Alt 8	20,000	4,000	9,000	-	33,000
Alt 9	21,000	10,000	77,000	-	108,000
Alt 10	20,000	10,000	-	34,000	64,000
Alt 11	20,000	42,000	-	144,700	206,700

[1]Minimum labor cost $20,000

5.7.3 – Net Present Value

In order to adequately assess the differences in costs, a net present value analysis is provided. The analysis is based on an interest rate of 5% for a term of 20 years.

Table 5.8 presents the net present value for all alternatives.

Alternative 11 assumes construction of the bio-filter in one of the existing south primary clarifiers. Although some credit has been given in the capital cost estimate above, it is possible that greater savings can be accrued.

Table 5.8
Net Present Value Analysis
Central WWTP

Alternative	Technology	Capital Cost ($)	Operating Cost ($)	Net Present Value ($)
Alt 0	None	0	1,432,000	17,842,720
Alt 1	Scrubber	854,000	993,000	13,226,780
Alt 2	Scrubber & Bio-filter	2,096,000	234,000	5,011,640
Alt 3	Scrubber	5,350,000	178,000	7,567,880
Alt 4	Bio-filter	6,335,000	88,400	7,436,464
Alt 5	Scrubber	6,485,000	646,000	14,534,160
Alt 6	Bio-filter	7,991,000	163,000	10,021,980
Alt 7	Scrubber	2,524,000	206,000	5,090,760
Alt 8	Scrubber	812,000	33,000	1,223,180
Alt 9	Scrubber	2,774,000	108,000	4,119,680
Alt 10	Bio-filter	3,327,000	64,000	4,124,440
Alt 11	Bio-filter	11,798,000	206,700	14,373,482

Section 6
Conclusions and Recommendations

6.1 - General

The odor and identification study verified that odors have been and are continuing to emanate from the treatment facility. The most significant sources at the treatment facility are:

1. The dewatering buildings
2. The exhaust from the head works scrubbers
3. The primary influent channel
4. The north and south primary clarifiers
5. The primary effluent channel
6. The screw pumps
7. The aeration influent channel
8. The aeration basins (during anoxic mode operation)
9. The old grit channel

During extremely stable air and low wind speeds (<1 m/s), the exhaust from the Central Pumping Station scrubber can also be a source of odors.

6.2 – Recommended Objective

Based on discussions with Metro staff, an objective of a D/T of 5 at the property boundary should be considered for all sources other than:

1. The north grit scrubbers – The proximity to the property boundary, in addition to the frequency of occurrence will cause frequent odor excursions. Based on a frequency analysis, low dispersion and calm air conditions will occur approximately 17% of the annual hours. This concludes in an odor migration off the property for approximately 1,500 hours per year.
2. The north primary clarifiers including the influent channel, both the quiescent and weir areas of the clarifiers and the effluent channel – same explanation as above.

The meteorological conditions assumed are a stability class of F and a wind speed of 1 meter/second.

6.3 – Recommended Project

Table 6.1 summarizes the net present values for each alternative calculated in Section 5. The net present values are grouped by total project for ease of comparison.

Table 6.1

Net Present Value Comparison

Description	Alt.	Capital Cost $	Operating Cost $/year	Net Present Value $
Do nothing alternative	0	0	1,432,000	17,842,720
Scrubber for the north grit area plus a scrubber for the primary influent channel, primary clarifier quiescent area, primary clarifier effluent weirs and a portion of the primary effluent channel plus a scrubber for the screw pumps plus a scrubber for the transfer channel (total four scrubbers)	1 + 3 + 7 + 8	9,540,000	1,410,000	27,108,600
Scrubber for the north grit area plus a scrubber for the primary influent channel, primary clarifier quiescent area, primary clarifier effluent weirs and a portion of the primary effluent channel plus a scrubber for the screw pumps and the transfer channel (total three scrubbers)	1 + 3 + 9	8,978,000	1,279,000	24,914,340
Bio-filter for the north grit scrubbers followed by a polishing scrubber plus a bio-filter for the primary influent channel, primary clarifier quiescent area, primary clarifier effluent weirs and a portion of the primary effluent channel plus a bio-filter for the screw pumps and the transfer channel (total 3 bio-filters and one scrubber)	2 + 4 + 10	11,758,000	386,400	16,572,544
Scrubber for the north grit area, the primary influent channel, primary clarifier quiescent area, primary clarifier effluent weirs and a portion of the primary effluent channel plus a scrubber for the screw pumps plus a scrubber for the transfer channel (total three scrubbers)	5 + 7 + 8	9,821,000	885,000	20,848,100
Scrubber for the north grit area, the primary influent channel, primary clarifier quiescent area, primary clarifier effluent weirs and a portion of the primary effluent channel plus a scrubber for the screw pumps and the transfer channel (total two scrubbers)	5 + 9	9,259,000	754,000	18,653,840
Bio-filter for the north grit, primary influent channel, primary clarifier quiescent area, primary clarifier effluent weirs and a portion of the primary effluent channel plus a bio-filter for the screw pumps and the transfer channel (total 2 bio-filters)	6 + 10	11,318,000	227,000	14,146,420
One bio-filter for the liquid train	11	11,798,000	206,700	14,373,482

Do Nothing Alternative – The do nothing alternative (Alt. 0) is not feasible. Complaints from the public and compliance with Metro Health Department requirements prompted this study, and some action is required to resolve these issues.

Bio-filters vs. Wet Scrubbers – In general, the bio-filter alternatives were the most cost effective. However, Alternative 9 (scrubber for the screw pumps and transfer channel) and Alternative 10 (bio-filter for the screw pumps and transfer channel) have virtually the same net present value. Therefore, the decision as to the selected technology must be based on factors other than cost. After lengthy discussions with Metro Water Services staff, the bio-filter alternative is recommended. The bio-filter alternative is more environmentally friendly because it uses a naturally occurring biological process to control odors. In addition, the use of similar technology for all of the odor control systems has some advantages.

The net present value of Alternatives 6 + 10 (two bio-filters) is comparable to Alternative 11 (one bio-filter). The increase in cost is due to the increase in duct length. Since the alternatives are relatively equal, the selection should be based on the ability to construct and maintain the system.

Recommended Alternative - Based on the alternatives analysis, the following project is recommended:

1. Abandon the existing mist scrubbers now collected air from the north grit area.
2. Cover the remaining portion of the primary influent channel, the primary clarifiers, the first third of the primary transfer channel and the screw pumps.
3. Based on the cost of operation, it is recommended that a bio-filter treating air from all of the significant sources listed above be installed. Since Water Services is willing to remove some of the south primary clarifiers from service on a permanent basis, the bio-filter could be installed in 1-1/2 of the existing basins. The preferable basins would be those closest to the screw pumps.

The estimated cost of the project is $11,798,000.

6.3.1 – Additional Recommendations

In addition to the above recommendations, the following is recommended:

- Central Pumping Station Scrubber – Due to the depth of the wet well, odors are not migrating from this source. In addition, this scrubber has poor removal efficiencies. It is therefore recommended that this scrubber be eliminated. There would appear to be no need to repair the scrubber that is presently out of service.
- Thickener Building Scrubber – This scrubber is also performing little to no service. Although fugitive emissions could occur from this structure due to the low ventilation rate, the odor emission rate is extremely low. The resultant odor will not migrate off the property

even during worst-case meteorological conditions.

6.4 – Recommendation Details

6.4.1 - Covers

The type of cover can either be aluminum, fiberglass or fabric. The choice is dependent on economics and preference. All have been used with satisfactory results.

It is recommended that specifications be written to allow all three types of covers, unless there is a preferred type.

Covers should be designed with the following considerations:

1. The removal of the cover(s) may be required in order to provide maintenance on the internal equipment or for the replacement of equipment. Consideration must be given, therefore, as to how the cover can be removed.
2. Adequate hatches should be provided to allow for inspection of the basins. The design should ensure that the hatches can be tightly sealed when closed.
3. If fabric covers are selected, adequate drainage should be provided.

6.4.2 - Ducting

Cost estimates for the ducting provide for separate duct runs from each odor source, rather than combining the sources into a single duct to the bio-filter. This concept provides for redundancy, and should be included in the final design.

Ducting from the various unit processes to the odor control systems should be constructed above ground to ensure that condensate does not collect in the low points of the duct. Drain ports for condensate drainage should be provided.

Since it would appear that road crossings will be required, adequate support should be designed since the height of the duct at the crossings could be considerable.

Dampers should be provided to allow for balancing of the system. These dampers should be able to be accurately adjusted to ensure proper balancing.

Since only one treatment unit is being recommended, duct design and layout will be important. As much separation as possible from each source from which air is being collected should occur to allow for varying collection schemes.

6.4.3 – Bio-filter Design

The following is recommended for the design of the bio-filter:

1. The bio-filter should be designed in at least three sections to allow for redundancy. Should one section be taken out of service for any reason, the foul air should be able to be directed to other sections of the bio-filter. Since the bio-filter's designed residence time is 40 seconds, eliminating one section will still allow for a residence time of 30 seconds.
2. A synthetic media is recommended to allow for reduced bio-filter size and longer media life. This type of media is more expensive than the older compost type media, but the

life is much longer (10 years compared to 3).

3. The bio-filter media should be pre-purchased to allow detailed design around one particular manufacturer. This will result in significantly lower engineering costs and will allow better control by Metro Water Services over the media selected. The media manufacturer should also furnish the air distribution system equipment, humidification equipment and fans in order to have a sole source of responsibility for the compliance of the bio-filtration system with the odor removal requirements.

Performance testing of the odor removal equipment should be required. Testing should occur after the equipment has been in operation for some period of time.

Figure 6.1
Central WWTP
Proposed Bio-filter Location

Focus Group Information

Central WWTP Focus Group

Mary Ellen Madary
Assistant Manager
Shoney's
Metro Center Blvd.

Joe "Robbie" Arnold
Crest Honda World
MetroCenter Blvd

Jeanece Seals
5th Ave North

Jimmy Rollins
4th Ave. North

Rick Murphy
Sixth Ave. N.

Stephen McRedmond
Neuhoff

Joe K. Moreland
Fourth Avenue, North

Reverend A. Thomas, Pastor
Salem A.M.E. Church
Fourth Avenue, North

Metro Water Services
Comprehensive Odor Study

Focus Group Meeting #1
Central WWTP

October 8, 2001

AGENDA

1. **Introductions**
2. **Establish Objectives of Focus Group**
3. **Definition of an Odor Problem**
4. **Brief Discussion on Odor Science**
5. **Odor Study Steps**
6. **Schedule of Tasks**
7. **Odor Occurrence Logs**
8. **Next Meeting Objectives and Potential Date**
9. **Discussion**

Definition of an Odor Problem

1. **Odor Source**
    - Incoming wastewater
    - Treatment processes within facility
2. **Release**
    - Open tanks
    - Channels
    - Vents
    - Fans
3. **Transport**
    - Meteorological conditions
    - Low wind speed
    - High stability
4. **Receptor (Nose)**
    - Location
    - Threshold of odor
    - Perception of odor

Basic Principles of Odor Science

1. **Odor constituents**

   - Odors from waste treatment facilities are comprised of numerous constituents
   - Constituents in low concentrations are not a concern to public health
   - Odors are considered a “nuisance”

2. Distance of **odor transport** dependent on “Odor emission rate” (OER) – OER is equal to the concentration of odor times the amount of air being emitted

3. **Threshold science**

   - Must reduce odor concentration below threshold concentration <u>at the receptor location</u>
   - Reducing the concentration well below the threshold could result in high costs with little additional benefit

4. Odors from different sources are **not necessarily additive**

   - Must determine the source (odor) which travels the farthest
   - Eliminating lesser odors will not provide benefit

Odor Study Steps

1. Determine all potential sources of odors
2. Sample and analyze air from all potential sources
3. Determine air exhaust rates from all potential sources
4. Calculate odor emission rates from each source
5. Rank all data (worst to best)
6. Model (screen) data to determine maximum distance that each odor (from each potential source) will travel during varying weather conditions
7. Establish Objectives - These objectives may include:
   - Acceptable odor level at: (1) receptors (off-site) or; (2) property line
   - Acceptable frequency of odor occurrences
   - Cost budget
8. Determine % removal to meet above objectives
9. Analyze and characterize odorous air from problem sources
10. Determine the alternatives for reducing odor (from each source) to meet above % removals
11. Evaluate alternatives based on:
    - Meeting above objectives
    - Cost
    - Long term implications
    - Other
12. Select alternative
13. Design

Schedule of Tasks

1. Determine all potential sources - complete
2. Sample and analyze air from all potential sources – complete
3. Determine air exhaust rates – 50 percent complete
4. Calculate odor emission rates – 50 percent complete
5. Determine distances – November, 2001
6. Odor Ranking – November, 2001
7. Technical Memorandum #1 – November, 2001
8. Focus Group Meeting #2 – November, 2001
9. % Removal Determination – December, 2001
10. Alternatives Screening – December, 2001
11. Technical Memorandum #2 – December, 2001
12. Focus Group Meeting #3 – December, 2001
13. Draft Report Preparation – January, 2002
14. Final Report – February, 2002

Focus Group Meeting #2

Preliminary Agenda

1. Review all data
2. Review modeling (screen) results
3. Establish Objectives

Comprehensive Odor Evaluation
Focus Group Meeting
January 28, 2002

AGENDA

1. Review Study Steps
2. Review Sample Locations
3. Discuss Sampling Results
4. Present Transport Model Results
5. Discuss Odor Priority
6. Discuss Abatement Objective

Model Results

Table 1
Base Data

Nashville - Metro Central

Name of Facility	Nashville - Metro Centra							
Date of Run	04/29/03							
Number of Sources	53							
Dilution Series 1	27	7	1					
Dilution Series 2	567	189	1					
Turbulence Factors	**None**	0.05	**Light**	0.1	**Moderate**	0.2	**High**	0
Endpoints	**Avg**	1	**Peak**	1	5			
Slope Correction	**Avg**	-0.5	**Peak**	-0.5	**Limiting D/T (1)**	100	**Limiting D/T (2)**	500
Peaking Factors	**Area**	10	**Point**	3	**Limiting OER (1)**	0.2	**Limiting OER (2)**	1
Design Average	x	5						
Design Peak	x	1						

Source Information — **Sample Type A,P or V** — **Factors: 1 = None 2 = Light 3 = Mod 4 = High**

Sample #	Sample Information: Sample Location	Date	Time	Sample Type	Factor	Process ID	D/T	Base Sensory Data: Dil 3	Dil 2	Dil 1	Dil Series	H2S	Mer	NH3	Source Information: Area	cfm	Height
1	N. Scrubber #1 - Exhaust	09/05/01	-	P	-	WSCRUB	392	117	251	888	2	60	-	0		8000	20
2	N. Scrubber #2 - Exhaust	09/26/01	-	P	-	WSCRUB	961	86	302	774	2	100	-	0		8000	20
3	N. Scrubber #3 - Exhaust	09/03/01	-	P	-	WSCRUB	200	32	60	72	1	0.5	-	0		8800	20
4	N. Scrubber #4 - Exhaust	09/03/01	-	P	-	WSCRUB	1146	348	705	767	1	55	-	0		2000	20
5	N. Primary Influent Channel	09/05/01	-	A	3	PRICH1	737	147	381	1669	2	6.5	-	0	2498		2
6	N. Primary Clarifier #16	09/04/01	-	A	1	PRIQ	133	87	135	272	1	0.33	5	0	41334		4
7	S. Primary Clarifier #14	09/04/01	-	A	1	PRIQ	284	18	30	55	1	0.013	0	0.25	51668		4
8	N. Primary Effluent Channel	09/05/01	-	A	3	PRICH2	282	53	115	636	2	48	-	0	24723		10
9	N. Primary Screw Pump	09/26/01	-	A	4	SCREW22	247	78	158	175	1	0.083	0	0	3400		30
10	S. Primary Screw Pump	09/26/01	-	A	4	SCREW22	243	59	80	104	1	0.06	0	0	3400		30
11	Aeration Basin #8 - Influent	08/29/01	-	V	-	AB3	6	9	10	11	1	0.005	0	0	46667	3333	10
12	Aeration Basin #8 - Mid	08/29/01	-	V	-	AB4	8	10	11	12	1	0.007	0	0	46667	3333	10
13	Aeration Basin #8 - Effluent	08/29/01	-	V	-	AB5	8	10	11	12	1	0.01	0	0	46667	3333	10
14	Aeration Basin (2) #8 - Influent	09/25/01	-	A	1	AB3	24	16	42	66	1	1.1	5	0	35000		10
15	Aeration Basin (2) #8 - Anoxic	09/25/01	-	A	1	AB2	100	135	247	768	1	2.2	5	0	35000		10
16	Aeration Basin (2) #8 - 1st Aerobic	09/25/01	-	V	-	AB3-1	33	15	23	39	1	0.045	0	0	23333	3333	10
17	Aeration Basin (2) #8 - Mid Aerobic	09/25/01	-	V	-	AB4-1	34	18	24	34	1	0.024	0	0	23333	3333	10
18	Aeration Basin (2) #8 - Effluent	09/25/01	-	V	-	AB5	17	10	11	11	1	0.011	0	0	23333	3333	10
19	N. Aeration Mixed Liquor Channel	09/25/01	-	A	3	FINCH	23	8	9	10	1	0.007	0	0	8000		10
20	N. Aeration Mixed Liquor Channel (2)	08/29/01	-	A	3	FINCH	8	8	9	10	1	0.004	0	0	8000		10
21	S. Scrubber #2 - #3 - Exhaust (2)	10/01/01	-	P	-	WSCRUB	6	8	11	19	1	0.005	0	0		10800	20
22	S. Scrubber #1 - Exhaust	10/01/01	-	P	-	WSCRUB	30	8	9	10	1	0.007	0	0		12000	20
23	N. Scrubber #4 - Exhaust (2)	10/02/01	-	P	-	WSCRUB	5	9	10	11	1	0.006	0	0		14500	20
24	N. Mixed Liquor Channel	10/02/01	-	A	3	FINCH	13	10	10	15	1	0.004	0	0	8000		10
25	N. Final Clarifier #7	10/02/01	-	A	1	FINQ	14	8	9	10	1	0.004	0	0	167768		2
26	Thickened Solids Wet Well	10/03/01	-	A	1	RSTORE	153	36	67	66	1	0.04	0	0	513		2
27	Thickener Building Exhaust	10/03/01	-	P	-	BPT	6	10	10	14	1	0.059	0	0.05		5000	10
28	Auxiliary Solids Bldg - No Permanganate	10/03/01	-	P	-	DWBP	111	47	101	461	2	32	0	0		9900	35
29	Auxiliary Solids Bldg. - With Permanganate (1)	10/03/01	-	P	-	DWBP	523	98	213	436	2	30	0	0		9900	35
30	Old Grit Channel	10/03/01	-	A	1	GR1	732	145	299	325	1	1.2	0	0	3400		2
31	Auxiliary Solids Bldg - With Permanganate	10/08/01	-	P	-	DWBP	325	162	420	475	1	4.8	5	0		9900	35
32	Auxiliary Solids Bldg - No Permanganate (2)	10/08/01	-	P	-	DWBP	84	50	176	1186	2	24	0	0		9900	35
33	Solids Wet Well	10/08/01	-	A	1	WAS	732	133	389	1087	2	13	0	0	300		20
34	Dewatered Sludge	10/16/01	-	A	1	RSTORE	458	97	144	200	1	0.27	0	0	1974		-
35	Central P. S. - Exhaust	10/22/01	-	P	-	WSCRUB	241	38	56	132	1	0	0	0		12000	35
36	Old Solids Bldg.	10/22/01	-	P	-	DWBP	211	122	292	346	1	0	0	0		20500	35
37	Solids Bldg Fan #12	10/22/01	-	P	-	NID	486	246	502	546	1	3	0	0		9900	35
38	Centrate Channel	10/22/01	-	A	1	NID	167	39	95	121	1	0	0	0	5680		2
39	Total North Scrubbers	-	-	P	-	WSCRUB	675	146	330	625	1	0	0	0		26800	2
40	Primary Clarifiers - Weir Area (Estimated)	-	-	A	2	PRIW	399	261	405	816	1				10333.5		2
41	Total Primary Clarifiers	-	-	A	2	TPRI	388	137	259	848	1	0	0	0	45795.5		2
42	Total Screw Pumps	-	-	A	4	SCREW22	423	165	307	919	1				6800		30
43	Total Aeration - Aerobic	-	-	A	-	TAER	245	69	119	140	1				164261	9999	10
44	Total Aeration - Anoxic	-	-	A	-	TAERA	304	82	144	665	1	-	-	-	164261	9999	10
45	Auxiliary Bldg (2)	-	-	P	-	DWBP	490	247	462	1554	1				156260	9999	35
46	Old Solids Bldg. (2)	-	-	P	-	DWBP	212	122	292	346	1	0	0	0		20500	35
47	New Solids Bldg (2)	-	-	P	-	DWBP	486	246	502	546	1					127200	35
48	Total Bldg. (1)	-	-	P	-	DWBP	341	177	405	456	1					157699	35
49	Total Bldg. (2)	-	-	P	-	DWBP	396	205	419	815	1					157699	35
50	Aeration Influent Channel	-	-	A	2	PRICH2	282	53	115	636	2	48	-	0	16260		10
51	Primary Effluent Channel - 1st 1/3	-	-	A	4	PRICH2	282	53	115	636	2	48	-	0	8241		
52	Primary Effluent Channel - 2nd 1/3	-	-	A	2	PRICH2	282	53	115	636	2	48	-	0	16482		
53	Total Primary Effluent Channel (2)	-	-	A	3	PRICH2	282	53	115	636	2	48	-	0	24723		

Table 2
Sensory Data

Nashville - Metro Central

Sample #	Sample Type	Sample Location	D/T	Dilutions			Dose -Response Data Logs				m	b	r	Test
1	P	N. Scrubber #1 - Exhaust	392	117	251	888	2.0682	2.3997	2.9484	2.5933	-0.3394	3.0412	-0.976	Okay
2	P	N. Scrubber #2 - Exhaust	961	86	302	774	1.9345	2.4800	2.8887	2.9827	-0.3199	2.9708	-0.903	Okay
3	P	N. Scrubber #3 - Exhaust	200	32	60	72	1.5051	1.7782	1.8573	2.3010	-0.1531	1.8297	-0.916	Okay
4	P	N. Scrubber #4 - Exhaust	1146	348	705	767	2.5416	2.8482	2.8848	3.0592	-0.1122	2.8433	-0.863	Check
5	A	N. Primary Influent Channel	737	147	381	1669	2.1673	2.5809	3.2225	2.8675	-0.3680	3.2739	-0.972	Okay
6	A	N. Primary Clarifier #16	133	87	135	272	1.9395	2.1303	2.4346	2.1239	-0.2331	2.3450	-1	Okay
7	A	S. Primary Clarifier #14	284	18	30	55	1.2553	1.4771	1.7404	2.4533	-0.1977	1.6410	-0.998	Okay
8	A	N. Primary Effluent Channel	282	53	115	636	1.7243	2.0607	2.8035	2.4502	-0.4404	2.9346	-0.989	Okay
9	A	N. Primary Screw Pump	247	78	158	175	1.8921	2.1987	2.2430	2.3927	-0.1467	2.2226	-0.872	Check
10	A	S. Primary Screw Pump	243	59	80	104	1.7709	1.9031	2.0170	2.3856	-0.1032	1.9753	-0.989	Okay
11	V	Aeration Basin #8 - Influent	6	9	10	11	0.9542	1.0000	1.0414	0.7782	-0.1120	1.0835	-0.991	Okay
12	V	Aeration Basin #8 - Mid	8	10	11	12	1.0000	1.0414	1.0792	0.9031	-0.0877	1.1067	-0.992	Okay
13	V	Aeration Basin #8 - Effluent	8	10	11	12	1.0000	1.0414	1.0792	0.9031	-0.0877	1.1067	-0.992	Okay
14	A	Aeration Basin (2) #8 - Influent	24	16	42	66	1.2041	1.6232	1.8195	1.3802	-0.4459	1.8873	-0.952	Okay
15	A	Aeration Basin (2) #8 - Anoxic	100	135	247	768	2.1303	2.3927	2.8854	2.0000	-0.3775	2.7559	-0.998	Okay
16	V	Aeration Basin (2) #8 - 1st Aerobic	33	15	23	39	1.1761	1.3617	1.5911	1.5185	-0.2733	1.5837	-0.999	Okay
17	V	Aeration Basin (2) #8 - Mid Aerobic	34	18	24	34	1.2553	1.3802	1.5315	1.5315	-0.1804	1.5258	-0.999	Okay
18	V	Aeration Basin (2) #8 - Effluent	17	10	11	11	1.0000	1.0414	1.0414	1.2304	-0.0336	1.0531	-0.809	Check
19	A	N. Aeration Mixed Liquor Channel	23	8	9	10	0.9031	0.9542	1.0000	1.3617	-0.0712	1.0064	-0.991	Okay
20	A	N. Aeration Mixed Liquor Channel (2)	8	8	9	10	0.9031	0.9542	1.0000	0.9031	-0.1073	1.0339	-0.991	Okay
21	P	S. Scrubber #2 - #3 - Exhaust (2)	6	8	11	19	0.9031	1.0414	1.2788	0.7782	-0.4828	1.4407	-0.999	Okay
22	P	S. Scrubber #1 - Exhaust	30	8	9	10	0.9031	0.9542	1.0000	1.4771	-0.0656	1.0022	-0.991	Okay
23	P	N. Scrubber #4 - Exhaust (2)	5	9	10	11	0.9542	1.0000	1.0414	0.6990	-0.1247	1.0932	-0.991	Okay
24	A	N. Mixed Liquor Channel	13	10	10	15	1.0000	1.0000	1.1761	1.1139	-0.1581	1.1787	-0.913	Okay
25	A	N. Final Clarifier #7	14	8	9	10	0.9031	0.9542	1.0000	1.1461	-0.0846	1.0166	-0.991	Okay
26	A	Thickened Solids Wet Well	153	36	67	66	1.5563	1.8261	1.8195	2.1847	-0.1205	1.8254	-0.797	Check
27	P	Thickener Building Exhaust	6	10	10	14	1.0000	1.0000	1.1461	0.7782	-0.1878	1.1912	-0.913	Okay
28	P	Auxiliary Solids Bldg - No Permanganate	111	47	101	461	1.6721	2.0043	2.6637	2.0453	-0.4848	2.4813	-0.996	Okay
29	P	Auxiliary Solids Bldg. - With Permanganate (1)	523	98	213	436	1.9912	2.3284	2.6395	2.7185	-0.2385	2.7195	-0.927	Okay
30	A	Old Grit Channel	732	145	299	325	2.1614	2.4757	2.5119	2.8645	-0.1224	2.5881	-0.704	Check
31	P	Auxiliary Solids Bldg - With Permanganate	325	162	420	475	2.2095	2.6232	2.6767	2.5119	-0.1860	2.6443	-0.866	Check
32	P	Auxiliary Solids Bldg - No Permanganate (2)	84	50	176	1186	1.6990	2.2455	3.0741	1.9243	-0.7146	2.8818	-1	Okay
33	A	Solids Wet Well	732	133	389	1087	2.1239	2.5899	3.0362	2.8645	-0.3185	3.1174	-0.931	Okay
34	A	Dewatered Sludge	458	97	144	200	1.9868	2.1584	2.3010	2.6609	-0.1181	2.3467	-0.916	Okay
35	P	Central P. S. - Exhaust	241	38	56	132	1.5798	1.7482	2.1206	2.3820	-0.2270	1.9885	-0.994	Okay
36	P	Old Solids Bldg.	211	122	292	346	2.0864	2.4654	2.5391	2.3243	-0.1948	2.5114	-0.889	Check
37	P	Solids Bldg Fan #12	486	246	502	546	2.3909	2.7007	2.7372	2.6866	-0.1289	2.7074	-0.862	Check
38	A	Centrate Channel	167	39	95	121	1.5911	1.9777	2.0828	2.2227	-0.2212	2.0517	-0.912	Okay
39	P	Total North Scrubbers	674.8	146	330	625	2.1636	2.5179	2.7961	2.8291	-0.2235	2.6621	-0.985	Okay
40	A	Primary Clarifiers - Weir Area (Estimated)	399	261	405	816	2.4166	2.6075	2.9117	2.6010	-0.1903	2.7897	-1	Okay
41	A	Total Primary Clarifiers	387.8	137	259	848	2.1367	2.4133	2.9285	2.5886	-0.3059	2.7250	-0.998	Okay
42	A	Total Screw Pumps	423	165	307	919	2.2175	2.4871	2.9633	2.6263	-0.2840	2.7715	-0.999	Okay
43	A	Total Aeration - Aerobic	245	69	119	140	1.8357	2.0755	2.1446	2.3892	-0.1293	2.1167	-0.916	Okay
44	A	Total Aeration - Anoxic	304	82	144	665	1.9138	2.1584	2.8228	2.4829	-0.3661	2.5761	-0.988	Okay
45	P	Auxiliary Bldg (2)	490	247	462	1554	2.3927	2.6646	3.1915	2.6902	-0.2969	2.9749	-0.997	Okay
46	P	Old Solids Bldg. (2)	212	122	292	346	2.0864	2.4654	2.5391	2.3263	-0.1946	2.5113	-0.889	Check
47	P	New Solids Bldg (2)	486	246	502	546	2.3909	2.7007	2.7372	2.6866	-0.1289	2.7074	-0.862	Check
48	P	Total Bldg. (1)	340.7	177	405	456	2.2472	2.6071	2.6586	2.5323	-0.1625	2.6276	-0.872	Check
49	P	Total Bldg. (2)	396	205	419	815	2.3118	2.6219	2.9113	2.5977	-0.2308	2.7901	-0.992	Okay
50	A	Aeration Influent Channel	282	53	115	636	1.7243	2.0607	2.8035	2.4502	-0.4404	2.5304	-0.994	Okay
51	A	Primary Effluent Channel - 1st 1/3	282	53	115	636	1.7243	2.0607	2.8035	2.4502	-0.4404	2.9346	-0.989	Okay
52	A	Primary Effluent Channel - 2nd 1/3	282	53	115	636	1.7243	2.0607	2.8035	2.4502	-0.4404	2.9346	-0.989	Okay
53	A	Total Primary Effluent Channel (2)	282	53	115	636	1.7243	2.0607	2.8035	2.4502	-0.4404	2.9346	-0.989	Okay

Table 3
Exhaust Rates

Nashville - Metro Central

Sample #	Sample Location	Sample Type	Area (ft^3)	Area (m^3)	Total Exhaust Rate (ft^3/min)	Total Exhaust Rate (m3/sec)	Unit Exhaust Rate (ft3/min/ft2)	Unit Exhaust Rate (m3/sec/m2)
1	N. Scrubber #1 - Exhaust	P			8000	3.78	Point	Point
2	N. Scrubber #2 - Exhaust	P			8000	3.78	Point	Point
3	N. Scrubber #3 - Exhaust	P			8800	4.15	Point	Point
#REF!	N. Scrubber #4 - Exhaust	P			2000	0.94	Point	Point
5	N. Primary Influent Channel	A	2498	232.06	500	0.24	0.200	0.0010
6	N. Primary Clarifier #16	A	41334	3839.93	2067	0.98	0.050	0.0003
7	S. Primary Clarifier #14	A	51668	4799.96	2583	1.22	0.050	0.0003
8	N. Primary Effluent Channel	A	24723	2296.77	4945	2.33	0.200	0.0010
9	N. Primary Screw Pump	A	3400	315.86	1020	0.48	0.300	0.0015
10	S. Primary Screw Pump	A	3400	315.86	1020	0.48	0.300	0.0015
11	Aeration Basin #8 - Influent	V	46667	4335.36	3333	1.57	0.071	0.0004
12	Aeration Basin #8 - Mid	V	46667	4335.36	3333	1.57	0.071	0.0004
13	Aeration Basin #8 - Effluent	V	46667	4335.36	3333	1.57	0.071	0.0004
14	Aeration Basin (2) #8 - Influent	A	35000	3251.50	1750	0.83	0.050	0.0003
15	Aeration Basin (2) #8 - Anoxic	A	35000	3251.50	1750	0.83	0.050	0.0003
16	Aeration Basin (2) #8 - 1st Aerobic	V	23333	2167.64	3333	1.57	0.143	0.0007
17	Aeration Basin (2) #8 - Mid Aerobic	V	23333	2167.64	3333	1.57	0.143	0.0007
18	Aeration Basin (2) #8 - Effluent	V	23333	2167.64	3333	1.57	0.143	0.0007
19	N. Aeration Mixed Liquor Channel	A	8000	743.20	1600	0.76	0.200	0.0010
20	N. Aeration Mixed Liquor Channel (2)	A	8000	743.20	1600	0.76	0.200	0.0010
21	S. Scrubber #2 - #3 - Exhaust (2)	P			10800	5.10	Point	Point
22	S. Scrubber #1 - Exhaust	P			12000	5.66	Point	Point
23	N. Scrubber #4 - Exhaust (2)	P			14500	6.84	Point	Point
24	N. Mixed Liquor Channel	A	8000	743.20	1600	0.76	0.200	0.0010
25	N. Final Clarifier #7	A	167768	15585.65	8388	3.96	0.050	0.0003
26	Thickened Solids Wet Well	A	513	47.66	26	0.01	0.050	0.0003
27	Thickener Building Exhaust	P			5000	2.36	Point	Point
28	Auxiliary Solids Bldg - No Permanganate	P			9900	4.67	Point	Point
29	Auxiliary Solids Bldg. - With Permanganate (1)	P			9900	4.67	Point	Point
30	Old Grit Channel	A	3400	315.86	170	0.08	0.050	0.0003
31	Auxiliary Solids Bldg - With Permanganate	P			9900	4.67	Point	Point
32	Auxiliary Solids Bldg - No Permanganate (2)	P			9900	4.67	Point	Point
33	Solids Wet Well	A	300	27.87	15	0.01	0.050	0.0003
34	Dewatered Sludge	A	1974	183.38	99	0.05	0.050	0.0003
35	Central P. S. - Exhaust	P			12000	5.66	Point	Point
36	Old Solids Bldg.	P			20500	9.68	Point	Point
37	Solids Bldg Fan #12	P			9900	4.67	Point	Point
38	Centrate Channel	A	5680	527.67	284	0.13	0.050	0.0003
39	Total North Scrubbers	P			26800	12.65	Point	Point
40	Primary Clarifiers - Weir Area (Estimated)	A	10333.5	959.98	1033	0.49	0.100	0.0005
41	Total Primary Clarifiers	A	45795.5	4254.40	4580	2.16	0.100	0.0005
42	Total Screw Pumps	A	6800	631.72	2040	0.96	0.300	0.0015
43	Total Aeration - Aerobic	A	164261	15259.85	49278	23.26	0.300	0.0015
44	Total Aeration - Anoxic	A	164261	15259.85	49278	23.26	0.300	0.0015
45	Auxiliary Bldg (2)	P	156260	14516.55	9999	4.72	Point	Point
46	Old Solids Bldg. (2)	P			20500	9.68	Point	Point
47	New Solids Bldg (2)	P			127200	60.04	Point	Point
48	Total Bldg. (1)	P			157699	74.43	Point	Point
49	Total Bldg. (2)	P			157699	74.43	Point	Point
50	Aeration Influent Channel	A	16260	1510.55	1626	0.77	0.100	0.0005
51	Primary Effluent Channel - 1st 1/3	A	8241	765.59	2472	1.17	0.300	0.0015
52	Primary Effluent Channel - 2nd 1/3	A	16482	1531.18	1648	0.78	0.100	0.0005
53	Total Primary Effluent Channel (2)	A	24723	2296.77	4945	2.33	0.200	0.0010

Table 4
Odor Emission Rates
Nashville - Metro Central

Sample #	Sample Location	Odor Emission Rate (O.U.-ft^3/min X 10^6)	Odor Emission Rate (O.U.-m^3/sec)	Butanol Odor Emission Rate (gr/sec)
1	N. Scrubber #1 - Exhaust	3.13600	1480.2	10.1
2	N. Scrubber #2 - Exhaust	7.68800	3628.7	8.8
3	N. Scrubber #3 - Exhaust	1.76000	830.7	0.9
#REF!	N. Scrubber #4 - Exhaust	2.29200	1081.8	2.2
5	N. Primary Influent Channel	0.36821	173.8	1.2
6	N. Primary Clarifier #16	0.27487	129.7	0.8
7	S. Primary Clarifier #14	0.73369	346.3	0.2
8	N. Primary Effluent Channel	1.39438	658.1	4.5
9	N. Primary Screw Pump	0.25194	118.9	0.3
10	S. Primary Screw Pump	0.24786	117.0	0.2
11	Aeration Basin #8 - Influent	0.02000	9.4	0.1
12	Aeration Basin #8 - Mid	0.02666	12.6	0.1
13	Aeration Basin #8 - Effluent	0.02666	12.6	0.1
14	Aeration Basin (2) #8 - Influent	0.04200	19.8	0.2
15	Aeration Basin (2) #8 - Anoxic	0.17500	82.6	1.9
16	Aeration Basin (2) #8 - 1st Aerobic	0.10999	51.9	0.2
17	Aeration Basin (2) #8 - Mid Aerobic	0.11332	53.5	0.2
18	Aeration Basin (2) #8 - Effluent	0.05666	26.7	0.1
19	N. Aeration Mixed Liquor Channel	0.03680	17.4	0.0
20	N. Aeration Mixed Liquor Channel (2)	0.01280	6.0	0.0
21	S. Scrubber #2 - #3 - Exhaust (2)	0.06480	30.6	0.3
22	S. Scrubber #1 - Exhaust	0.36000	169.9	0.2
23	N. Scrubber #4 - Exhaust (2)	0.07250	34.2	0.2
24	N. Mixed Liquor Channel	0.02080	9.8	0.0
25	N. Final Clarifier #7	0.11744	55.4	0.1
26	Thickened Solids Wet Well	0.00392	1.9	0.0
27	Thickener Building Exhaust	0.03000	14.2	0.1
28	Auxiliary Solids Bldg - No Permanganate	1.09890	518.7	6.5
29	Auxiliary Solids Bldg. - With Permanganate (1)	5.17770	2443.9	6.2
30	Old Grit Channel	0.12444	58.7	0.1
31	Auxiliary Solids Bldg - With Permanganate	3.21750	1518.7	6.7
32	Auxiliary Solids Bldg - No Permanganate (2)	0.83160	392.5	16.7
33	Solids Wet Well	0.01098	5.2	0.0
34	Dewatered Sludge	0.04520	21.3	0.0
35	Central P. S. - Exhaust	2.89200	1365.0	2.3
36	Old Solids Bldg.	4.32550	2041.6	10.1
37	Solids Bldg Fan #12	4.81140	2271.0	7.7
38	Centrate Channel	0.04743	22.4	0.0
39	Total North Scrubbers	14.87600	7021.5	22.0
40	Primary Clarifiers - Weir Area (Estimated)	0.41231	194.6	1.2
41	Total Primary Clarifiers	1.75257	827.2	5.4
42	Total Screw Pumps	0.49980	235.9	0.4
43	Total Aeration - Aerobic	0.55266	260.9	1.7
44	Total Aeration - Anoxic	0.99230	468.4	4.0
45	Auxiliary Bldg (2)	4.89951	2312.6	22.2
46	Old Solids Bldg. (2)	4.34600	2051.3	10.1
47	New Solids Bldg (2)	61.81920	29178.7	99.0
48	Total Bldg. (1)	14.31460	6756.5	24.0
49	Total Bldg. (2)	85.37931	40299.0	155.2
50	Aeration Influent Channel	0.45853	216.4	1.5
51	Primary Effluent Channel - 1st 1/3	0.69719	329.1	2.2
52	Primary Effluent Channel - 2nd 1/3	0.46479	219.4	1.5
53	Total Primary Effluent Channel (2)	1.16198	548.5	3.7

Table 5
D/T Sort

Nashville - Metro Central

Sample #	Sample Location	D/T	Sample #	Sample Location	D/T	Rank
1	N. Scrubber #1 - Exhaust	392	4	N. Scrubber #4 - Exhaust	1146	1
2	N. Scrubber #2 - Exhaust	961	2	N. Scrubber #2 - Exhaust	961	2
3	N. Scrubber #3 - Exhaust	200	5	N. Primary Influent Channe	737	3
4	N. Scrubber #4 - Exhaust	1146	30	Old Grit Channel	732	4
5	N. Primary Influent Channe	737	33	Solids Wet Well	732	5
6	N. Primary Clarifier #16	133	39	Total North Scrubbers	675	6
7	S. Primary Clarifier #14	284	29	Auxiliary Solids Bldg. - With Permanganate (1	523	7
8	N. Primary Effluent Channe	282	45	Auxiliary Bldg (2)	490	8
9	N. Primary Screw Pump	247	37	Solids Bldg Fan #12	486	9
10	S. Primary Screw Pump	243	47	New Solids Bldg (2)	486	10
11	Aeration Basin #8 - Influent	6	34	Dewatered Sludge	458	11
12	Aeration Basin #8 - Mid	8	42	Total Screw Pumps	423	12
13	Aeration Basin #8 - Effluent	8	40	Primary Clarifiers - Weir Area (Estimated)	399	13
14	Aeration Basin (2) #8 - Influent	24	49	Total Bldg. (2)	396	14
15	Aeration Basin (2) #8 - Anoxic	100	1	N. Scrubber #1 - Exhaust	392	15
16	Aeration Basin (2) #8 - 1st Aerobic	33	41	Total Primary Clarifiers	388	16
17	Aeration Basin (2) #8 - Mid Aerobic	34	48	Total Bldg. (1)	341	17
18	Aeration Basin (2) #8 - Effluent	17	31	Auxiliary Solids Bldg - With Permanganate	325	18
19	N. Aeration Mixed Liquor Channel	23	44	Total Aeration - Anoxic	304	19
20	N. Aeration Mixed Liquor Channel (2)	8	7	S. Primary Clarifier #14	284	20
21	S. Scrubber #2 - #3 - Exhaust (2)	6	8	N. Primary Effluent Channe	282	21
22	S. Scrubber #1 - Exhaust	30	50	Aeration Influent Channel	282	22
23	N. Scrubber #4 - Exhaust (2)	5	51	Primary Effluent Channel - 1st 1/3	282	23
24	N. Mixed Liquor Channel	13	52	Primary Effluent Channel - 2nd 1/3	282	24
25	N. Final Clarifier #7	14	53	Total Primary Effluent Channel (2)	282	25
26	Thickened Solids Wet Well	153	9	N. Primary Screw Pump	247	26
27	Thickener Building Exhaust	6	43	Total Aeration - Aerobic	245	27
28	Auxiliary Solids Bldg - No Permanganate	111	10	S. Primary Screw Pump	243	28
29	Auxiliary Solids Bldg. - With Permanganate (1	523	35	Central P. S. - Exhaust	241	29
30	Old Grit Channel	732	46	Old Solids Bldg. (2)	212	30
31	Auxiliary Solids Bldg - With Permanganate	325	36	Old Solids Bldg.	211	31
32	Auxiliary Solids Bldg - No Permanganate (2	84	3	N. Scrubber #3 - Exhaust	200	32
33	Solids Wet Well	732	38	Centrate Channel	167	33
34	Dewatered Sludge	458	26	Thickened Solids Wet Well	153	34
35	Central P. S. - Exhaust	241	6	N. Primary Clarifier #16	133	35
36	Old Solids Bldg.	211	28	Auxiliary Solids Bldg - No Permanganate	111	36
37	Solids Bldg Fan #12	486	15	Aeration Basin (2) #8 - Anoxic	100	37
38	Centrate Channel	167	32	Auxiliary Solids Bldg - No Permanganate (2	84	38
39	Total North Scrubbers	675	17	Aeration Basin (2) #8 - Mid Aerobic	34	39
40	Primary Clarifiers - Weir Area (Estimated)	399	16	Aeration Basin (2) #8 - 1st Aerobic	33	40
41	Total Primary Clarifiers	388	22	S. Scrubber #1 - Exhaust	30	41
42	Total Screw Pumps	423	14	Aeration Basin (2) #8 - Influent	24	42
43	Total Aeration - Aerobic	245	19	N. Aeration Mixed Liquor Channel	23	43
44	Total Aeration - Anoxic	304	18	Aeration Basin (2) #8 - Effluent	17	44
45	Auxiliary Bldg (2)	490	25	N. Final Clarifier #7	14	45
46	Old Solids Bldg. (2)	212	24	N. Mixed Liquor Channel	13	46
47	New Solids Bldg (2)	486	12	Aeration Basin #8 - Mid	8	47
48	Total Bldg. (1)	341	13	Aeration Basin #8 - Effluent	8	48
49	Total Bldg. (2)	396	20	N. Aeration Mixed Liquor Channel (2)	8	49
50	Aeration Influent Channel	282	11	Aeration Basin #8 - Influent	6	50
51	Primary Effluent Channel - 1st 1/3	282	21	S. Scrubber #2 - #3 - Exhaust (2)	6	51
52	Primary Effluent Channel - 2nd 1/3	282	27	Thickener Building Exhaust	6	52
53	Total Primary Effluent Channel (2)	282	23	N. Scrubber #4 - Exhaust (2)	5	53

Table 6
OER Sort

Nashville - Metro Central

Sample #	Sample Location	OER	Sample #	Sample Location	OER	Rank
1	N. Scrubber #1 - Exhaust	3.13600	49	Total Bldg. (2)	85.379	1
2	N. Scrubber #2 - Exhaust	7.68800	47	New Solids Bldg (2)	61.819	2
3	N. Scrubber #3 - Exhaust	1.76000	39	Total North Scrubbers	14.876	3
4	N. Scrubber #4 - Exhaust	2.29200	48	Total Bldg. (1)	14.315	4
5	N. Primary Influent Channe	0.36821	2	N. Scrubber #2 - Exhaust	7.688	5
6	N. Primary Clarifier #16	0.27487	29	Auxiliary Solids Bldg. - With Permanganate (1	5.178	6
7	S. Primary Clarifier #14	0.73369	45	Auxiliary Bldg (2)	4.900	7
8	N. Primary Effluent Channe	1.39438	37	Solids Bldg Fan #12	4.811	8
9	N. Primary Screw Pump	0.25194	46	Old Solids Bldg. (2)	4.346	9
10	S. Primary Screw Pump	0.24786	36	Old Solids Bldg.	4.326	10
11	Aeration Basin #8 - Influent	0.02000	31	Auxiliary Solids Bldg - With Permanganate	3.218	11
12	Aeration Basin #8 - Mid	0.02666	1	N. Scrubber #1 - Exhaust	3.136	12
13	Aeration Basin #8 - Effluent	0.02666	35	Central P. S. - Exhaust	2.892	13
14	Aeration Basin (2) #8 - Influent	0.04200	4	N. Scrubber #4 - Exhaust	2.292	14
15	Aeration Basin (2) #8 - Anoxic	0.17500	3	N. Scrubber #3 - Exhaust	1.760	15
16	Aeration Basin (2) #8 - 1st Aerobic	0.10999	41	Total Primary Clarifiers	1.753	16
17	Aeration Basin (2) #8 - Mid Aerobic	0.11332	8	N. Primary Effluent Channe	1.394	17
18	Aeration Basin (2) #8 - Effluent	0.05666	53	Total Primary Effluent Channel (2	1.162	18
19	N. Aeration Mixed Liquor Channel	0.03680	28	Auxiliary Solids Bldg - No Permanganate	1.099	19
20	N. Aeration Mixed Liquor Channel (2)	0.01280	44	Total Aeration - Anoxic	0.992	20
21	S. Scrubber #2 - #3 - Exhaust (2)	0.06480	32	Auxiliary Solids Bldg - No Permanganate (2	0.832	21
22	S. Scrubber #1 - Exhaust	0.36000	7	S. Primary Clarifier #14	0.734	22
23	N. Scrubber #4 - Exhaust (2)	0.07250	51	Primary Effluent Channel - 1st 1/3	0.697	23
24	N. Mixed Liquor Channel	0.02080	43	Total Aeration - Aerobic	0.553	24
25	N. Final Clarifier #7	0.11744	42	Total Screw Pumps	0.500	25
26	Thickened Solids Wet Well	0.00392	52	Primary Effluent Channel - 2nd 1/3	0.465	26
27	Thickener Building Exhaust	0.03000	50	Aeration Influent Channel	0.459	27
28	Auxiliary Solids Bldg - No Permanganate	1.09890	40	Primary Clarifiers - Weir Area (Estimated)	0.412	28
29	Auxiliary Solids Bldg. - With Permanganate (1	5.17770	5	N. Primary Influent Channe	0.368	29
30	Old Grit Channel	0.12444	22	S. Scrubber #1 - Exhaust	0.360	30
31	Auxiliary Solids Bldg - With Permanganate	3.21750	6	N. Primary Clarifier #16	0.275	31
32	Auxiliary Solids Bldg - No Permanganate (2	0.83160	9	N. Primary Screw Pump	0.252	32
33	Solids Wet Well	0.01098	10	S. Primary Screw Pump	0.248	33
34	Dewatered Sludge	0.04520	15	Aeration Basin (2) #8 - Anoxic	0.175	34
35	Central P. S. - Exhaust	2.89200	30	Old Grit Channel	0.124	35
36	Old Solids Bldg.	4.32550	25	N. Final Clarifier #7	0.117	36
37	Solids Bldg Fan #12	4.81140	17	Aeration Basin (2) #8 - Mid Aerobic	0.113	37
38	Centrate Channel	0.04743	16	Aeration Basin (2) #8 - 1st Aerobic	0.110	38
39	Total North Scrubbers	#######	23	N. Scrubber #4 - Exhaust (2)	0.073	39
40	Primary Clarifiers - Weir Area (Estimated)	0.41231	21	S. Scrubber #2 - #3 - Exhaust (2)	0.065	40
41	Total Primary Clarifiers	1.75257	18	Aeration Basin (2) #8 - Effluent	0.057	41
42	Total Screw Pumps	0.49980	38	Centrate Channel	0.047	42
43	Total Aeration - Aerobic	0.55266	34	Dewatered Sludge	0.045	43
44	Total Aeration - Anoxic	0.99230	14	Aeration Basin (2) #8 - Influent	0.042	44
45	Auxiliary Bldg (2)	4.89951	19	N. Aeration Mixed Liquor Channel	0.037	45
46	Old Solids Bldg. (2)	4.34600	27	Thickener Building Exhaust	0.030	46
47	New Solids Bldg (2)	#######	12	Aeration Basin #8 - Mid	0.027	47
48	Total Bldg. (1)	#######	13	Aeration Basin #8 - Effluent	0.027	48
49	Total Bldg. (2)	#######	24	N. Mixed Liquor Channel	0.021	49
50	Aeration Influent Channel	0.45853	11	Aeration Basin #8 - Influent	0.020	50
51	Primary Effluent Channel - 1st 1/3	0.69719	20	N. Aeration Mixed Liquor Channel (2)	0.013	51
52	Primary Effluent Channel - 2nd 1/3	0.46479	33	Solids Wet Well	0.011	52
53	Total Primary Effluent Channel (2	1.16198	26	Thickened Solids Wet Well	0.004	53

Table 7
Intensity Sort

Nashville - Metro Central

Sample #	Sample Location	Intensity	Sample #	Sample Location	Intensity	Rank
1	N. Scrubber #1 - Exhaust	10.128	49	Total Bldg. (2)	155.248	1
2	N. Scrubber #2 - Exhaust	8.828	47	New Solids Bldg (2)	99.012	2
3	N. Scrubber #3 - Exhaust	0.903	48	Total Bldg. (1)	23.972	3
4	N. Scrubber #4 - Exhaust	2.187	45	Auxiliary Bldg (2)	22.152	4
5	N. Primary Influent Channe	1.189	39	Total North Scrubbers	22.045	5
6	N. Primary Clarifier #16	0.801	32	Auxiliary Solids Bldg - No Permanganate (2)	16.739	6
7	S. Primary Clarifier #14	0.203	1	N. Scrubber #1 - Exhaust	10.128	7
8	N. Primary Effluent Channe	4.483	36	Old Solids Bldg.	10.112	8
9	N. Primary Screw Pump	0.254	46	Old Solids Bldg. (2)	10.112	9
10	S. Primary Screw Pump	0.151	2	N. Scrubber #2 - Exhaust	8.828	10
11	Aeration Basin #8 - Influent	0.052	37	Solids Bldg Fan #12	7.706	11
12	Aeration Basin #8 - Mid	0.057	31	Auxiliary Solids Bldg - With Permanganate	6.704	12
13	Aeration Basin #8 - Effluent	0.057	28	Auxiliary Solids Bldg - No Permanganate	6.506	13
14	Aeration Basin (2) #8 - Influent	0.165	29	Auxiliary Solids Bldg. - With Permanganate (1	6.154	14
15	Aeration Basin (2) #8 - Anoxic	1.916	41	Total Primary Clarifiers	5.434	15
16	Aeration Basin (2) #8 - 1st Aerobic	0.185	8	N. Primary Effluent Channe	4.483	16
17	Aeration Basin (2) #8 - Mid Aerobic	0.162	44	Total Aeration - Anoxic	3.977	17
18	Aeration Basin (2) #8 - Effluent	0.052	53	Total Primary Effluent Channel (2)	3.736	18
19	N. Aeration Mixed Liquor Channel	0.023	35	Central P. S. - Exhaust	2.258	19
20	N. Aeration Mixed Liquor Channel (2)	0.023	51	Primary Effluent Channel - 1st 1/3	2.242	20
21	S. Scrubber #2 - #3 - Exhaust (2)	0.293	4	N. Scrubber #4 - Exhaust	2.187	21
22	S. Scrubber #1 - Exhaust	0.171	15	Aeration Basin (2) #8 - Anoxic	1.916	22
23	N. Scrubber #4 - Exhaust (2)	0.227	43	Total Aeration - Aerobic	1.675	23
24	N. Mixed Liquor Channel	0.034	52	Primary Effluent Channel - 2nd 1/3	1.494	24
25	N. Final Clarifier #7	0.120	50	Aeration Influent Channe	1.474	25
26	Thickened Solids Wet Well	0.002	40	Primary Clarifiers - Weir Area (Estimated)	1.202	26
27	Thickener Building Exhaus	0.100	5	N. Primary Influent Channe	1.189	27
28	Auxiliary Solids Bldg - No Permanganate	6.506	3	N. Scrubber #3 - Exhaust	0.903	28
29	Auxiliary Solids Bldg. - With Permanganate (1	6.154	6	N. Primary Clarifier #16	0.801	29
30	Old Grit Channel	0.079	42	Old Grit Channel	0.406	30
31	Auxiliary Solids Bldg - With Permanganate	6.704	21	Auxiliary Solids Bldg - With Permanganate	0.293	31
32	Auxiliary Solids Bldg - No Permanganate (2)	16.739	9	Auxiliary Solids Bldg - No Permanganate (2)	0.254	32
33	Solids Wet Well	0.023	23	Solids Wet Well	0.227	33
34	Dewatered Sludge	0.028	7	Dewatered Sludge	0.203	34
35	Central P. S. - Exhaust	2.258	16	Central P. S. - Exhaust	0.185	35
36	Old Solids Bldg.	10.112	22	Old Solids Bldg.	0.171	36
37	Solids Bldg Fan #12	7.706	14	Solids Bldg Fan #12	0.165	37
38	Centrate Channel	0.049	17	Centrate Channel	0.162	38
39	Total North Scrubbers	22.045	10	Total North Scrubbers	0.151	39
40	Primary Clarifiers - Weir Area (Estimated)	1.202	25	Primary Clarifiers - Weir Area (Estimated)	0.120	40
41	Total Primary Clarifiers	5.434	27	Total Primary Clarifiers	0.100	41
42	Total Screw Pumps	0.406	30	Total Screw Pumps	0.079	42
43	Total Aeration - Aerobic	1.675	12	Total Aeration - Aerobic	0.057	43
44	Total Aeration - Anoxic	3.977	13	Total Aeration - Anoxic	0.057	44
45	Auxiliary Bldg (2)	22.152	11	Auxiliary Bldg (2)	0.052	45
46	Old Solids Bldg. (2)	10.112	18	Old Solids Bldg. (2)	0.052	46
47	New Solids Bldg (2)	99.012	38	New Solids Bldg (2)	0.049	47
48	Total Bldg. (1)	23.972	24	Total Bldg. (1)	0.034	48
49	Total Bldg. (2)	155.248	34	Total Bldg. (2)	0.028	49
50	Aeration Influent Channe	1.474	19	Aeration Influent Channe	0.023	50
51	Primary Effluent Channel - 1st 1/3	2.242	33	Primary Effluent Channel - 1st 1/3	0.023	51
52	Primary Effluent Channel - 2nd 1/3	1.494	20	Primary Effluent Channel - 2nd 1/3	0.023	52
53	Total Primary Effluent Channel (2)	3.736	26	Total Primary Effluent Channel (2)	0.002	53

Table 8
Combined Sort

Nashville - Metro Central

D/T Sample Location	OER Sample Location	Intensity Sample Location
N. Scrubber #4 - Exhaust	Total Bldg. (2)	Total Bldg. (2)
N. Scrubber #2 - Exhaust	New Solids Bldg (2)	New Solids Bldg (2)
N. Primary Influent Channe	Total North Scrubbers	Total Bldg. (1)
Old Grit Channel	Total Bldg. (1)	Auxiliary Bldg (2)
Solids Wet Well	N. Scrubber #2 - Exhaust	Total North Scrubbers
Total North Scrubbers	Auxiliary Solids Bldg. - With Permanganate (1	Auxiliary Solids Bldg - No Permanganate (2
Auxiliary Solids Bldg. - With Permanganate (1	Auxiliary Bldg (2)	N. Scrubber #1 - Exhaust
Auxiliary Bldg (2)	Solids Bldg Fan #12	Old Solids Bldg.
Solids Bldg Fan #12	Old Solids Bldg. (2)	Old Solids Bldg. (2)
New Solids Bldg (2)	Old Solids Bldg.	N. Scrubber #2 - Exhaust
Dewatered Sludge	Auxiliary Solids Bldg - With Permanganate	Solids Bldg Fan #12
Total Screw Pumps	N. Scrubber #1 - Exhaust	Auxiliary Solids Bldg - With Permanganate
Primary Clarifiers - Weir Area (Estimated)	Central P. S. - Exhaust	Auxiliary Solids Bldg - No Permanganate
Total Bldg. (2)	N. Scrubber #4 - Exhaust	Auxiliary Solids Bldg. - With Permanganate (1
N. Scrubber #1 - Exhaust	N. Scrubber #3 - Exhaust	Total Primary Clarifiers
Total Primary Clarifiers	Total Primary Clarifiers	N. Primary Effluent Channe
Total Bldg. (1)	N. Primary Effluent Channe	Total Aeration - Anoxic
Auxiliary Solids Bldg - With Permanganate	Total Primary Effluent Channel (2	Total Primary Effluent Channel (2
Total Aeration - Anoxic	Auxiliary Solids Bldg - No Permanganate	Central P. S. - Exhaust
S. Primary Clarifier #14	Total Aeration - Anoxic	Primary Effluent Channel - 1st 1/3
N. Primary Effluent Channe	Auxiliary Solids Bldg - No Permanganate (2	N. Scrubber #4 - Exhaust
Aeration Influent Channel	S. Primary Clarifier #14	Aeration Basin (2) #8 - Anoxic
Primary Effluent Channel - 1st 1/3	Primary Effluent Channel - 1st 1/3	Total Aeration - Aerobic
Primary Effluent Channel - 2nd 1/3	Total Aeration - Aerobic	Primary Effluent Channel - 2nd 1/3
Total Primary Effluent Channel (2	Total Screw Pumps	Aeration Influent Channel
N. Primary Screw Pump	Primary Effluent Channel - 2nd 1/3	Primary Clarifiers - Weir Area (Estimated)
Total Aeration - Aerobic	Aeration Influent Channe	N. Primary Influent Channe
S. Primary Screw Pump	Primary Clarifiers - Weir Area (Estimated)	N. Scrubber #3 - Exhaust
Central P. S. - Exhaust	N. Primary Influent Channe	N. Primary Clarifier #16
Old Solids Bldg. (2)	S. Scrubber #1 - Exhaust	Old Grit Channel
Old Solids Bldg.	N. Primary Clarifier #16	Auxiliary Solids Bldg - With Permanganate
N. Scrubber #3 - Exhaust	N. Primary Screw Pump	Auxiliary Solids Bldg - No Permanganate (2
Centrate Channel	S. Primary Screw Pump	Solids Wet Well
Thickened Solids Wet Well	Aeration Basin (2) #8 - Anoxic	Dewatered Sludge
N. Primary Clarifier #16	Old Grit Channel	Central P. S. - Exhaust
Auxiliary Solids Bldg - No Permanganate	N. Final Clarifier #7	Old Solids Bldg.
Aeration Basin (2) #8 - Anoxic	Aeration Basin (2) #8 - Mid Aerobic	Solids Bldg Fan #12
Auxiliary Solids Bldg - No Permanganate (2	Aeration Basin (2) #8 - 1st Aerobic	Centrate Channel
Aeration Basin (2) #8 - Mid Aerobic	N. Scrubber #4 - Exhaust (2)	Total North Scrubbers
Aeration Basin (2) #8 - 1st Aerobic	S. Scrubber #2 - #3 - Exhaust (2)	Primary Clarifiers - Weir Area (Estimated)
S. Scrubber #1 - Exhaust	Aeration Basin (2) #8 - Effluent	Total Primary Clarifiers
Aeration Basin (2) #8 - Influent	Centrate Channel	Total Screw Pumps
N. Aeration Mixed Liquor Channel	Dewatered Sludge	Total Aeration - Aerobic
Aeration Basin (2) #8 - Effluent	Aeration Basin (2) #8 - Influent	Total Aeration - Anoxic
N. Final Clarifier #7	N. Aeration Mixed Liquor Channel	Auxiliary Bldg (2)
N. Mixed Liquor Channel	Thickener Building Exhaust	Old Solids Bldg. (2)
Aeration Basin #8 - Mid	Aeration Basin #8 - Mid	New Solids Bldg (2)
Aeration Basin #8 - Effluent	Aeration Basin #8 - Effluent	Total Bldg. (1)
N. Aeration Mixed Liquor Channel (2)	N. Mixed Liquor Channel	Total Bldg. (2)
Aeration Basin #8 - Influent	Aeration Basin #8 - Influent	Aeration Influent Channel
S. Scrubber #2 - #3 - Exhaust (2)	N. Aeration Mixed Liquor Channel (2)	Primary Effluent Channel - 1st 1/3
Thickener Building Exhaust	Solids Wet Well	Primary Effluent Channel - 2nd 1/3
N. Scrubber #4 - Exhaust (2)	Thickened Solids Wet Well	Total Primary Effluent Channel (2

Table 9
Average Model Input Data
Nashville - Metro Central

Sample #	Sample Location	Initial D/T x m3/sec	Final D/T x m3/sec	Slope Correction	Final Endpoint
49	Total Bldg. (2)	40299.03	1.00	-0.5	0.462
47	New Solids Bldg (2)	29178.66	1.00	-0.5	0.258
39	Total North Scrubbers	7021.47	1.00	-0.5	0.447
48	Total Bldg. (1)	6756.49	1.00	-0.5	0.325
2	N. Scrubber #2 - Exhaust	3628.74	1.00	-0.5	0.640
29	Auxiliary Solids Bldg. - With Permanganate (1)	2443.87	1.00	-0.5	0.477
45	Auxiliary Bldg (2)	2312.57	1.00	-0.5	0.594
37	Solids Bldg Fan #12	2270.98	1.00	-0.5	0.258
46	Old Solids Bldg. (2)	2051.31	1.00	-0.5	0.389
36	Old Solids Bldg.	2041.64	1.00	-0.5	0.390
31	Auxiliary Solids Bldg - With Permanganate	1518.66	1.00	-0.5	0.372
1	N. Scrubber #1 - Exhaust	1480.19	1.00	-0.5	0.679
35	Central P. S. - Exhaust	1365.02	1.00	-0.5	0.454
4	N. Scrubber #4 - Exhaust	1081.82	1.00	-0.5	0.224
3	N. Scrubber #3 - Exhaust	830.72	1.00	-0.5	0.306
41	Total Primary Clarifiers	827.21	1.00	-0.5	0.612
8	N. Primary Effluent Channel	658.15	1.00	-0.5	0.881
53	Total Primary Effluent Channel (2)	548.46	1.00	-0.5	0.881
28	Auxiliary Solids Bldg - No Permanganate	518.68	1.00	-0.5	0.970
44	Total Aeration - Anoxic	468.37	1.00	-0.5	0.732
32	Auxiliary Solids Bldg - No Permanganate (2)	392.52	1.00	-0.5	1.429
7	S. Primary Clarifier #14	346.30	1.00	-0.5	0.395
51	Primary Effluent Channel - 1st 1/3	329.07	1.00	-0.5	0.881
43	Total Aeration - Aerobic	260.85	1.00	-0.5	0.259
42	Total Screw Pumps	235.91	1.00	-0.5	0.568
52	Primary Effluent Channel - 2nd 1/3	219.38	1.00	-0.5	0.881
50	Aeration Influent Channel	216.43	1.00	-0.5	0.881
40	Primary Clarifiers - Weir Area (Estimated)	194.61	1.00	-0.5	0.381
5	N. Primary Influent Channel	173.79	1.00	-0.5	0.736
22	S. Scrubber #1 - Exhaust	169.92	1.00	-0.5	0.131
6	N. Primary Clarifier #16	129.74	1.00	-0.5	0.466
9	N. Primary Screw Pump	118.92	1.00	-0.5	0.293
10	S. Primary Screw Pump	116.99	1.00	-0.5	0.206
15	Aeration Basin (2) #8 - Anoxic	82.60	1.00	-0.5	0.755
30	Old Grit Channel	58.74	1.00	-0.5	0.245
25	N. Final Clarifier #7	55.43	1.00	-0.5	0.169
17	Aeration Basin (2) #8 - Mid Aerobic	53.49	1.00	-0.5	0.361
16	Aeration Basin (2) #8 - 1st Aerobic	51.91	1.00	-0.5	0.547
23	N. Scrubber #4 - Exhaust (2)	34.22	1.00	-0.5	0.249
21	S. Scrubber #2 - #3 - Exhaust (2)	30.59	1.00	-0.5	0.966
18	Aeration Basin (2) #8 - Effluent	26.74	1.00	-0.5	0.067
38	Centrate Channel	22.39	1.00	-0.5	0.442
34	Dewatered Sludge	21.34	1.00	-0.5	0.236
14	Aeration Basin (2) #8 - Influent	19.82	1.00	-0.5	0.892
19	N. Aeration Mixed Liquor Channel	17.37	1.00	-0.5	0.142
27	Thickener Building Exhaust	14.16	1.00	-0.5	0.376
12	Aeration Basin #8 - Mid	12.59	1.00	-0.5	0.175
13	Aeration Basin #8 - Effluent	12.59	1.00	-0.5	0.175
24	N. Mixed Liquor Channel	9.82	1.00	-0.5	0.316
11	Aeration Basin #8 - Influent	9.44	1.00	-0.5	0.224
20	N. Aeration Mixed Liquor Channel (2)	6.04	1.00	-0.5	0.215
33	Solids Wet Well	5.18	1.00	-0.5	0.637
26	Thickened Solids Wet Well	1.85	1.00	-0.5	0.241

Table 10
Peak Model Input Data
Nashville - Metro Central

Sample #	Sample Location	Initial D/T x m3/sec	Final Endpoint
49	Total Bldg. (2)	120897.10	1.00
47	New Solids Bldg (2)	87535.99	1.00
39	Total North Scrubbers	21064.42	1.00
48	Total Bldg. (1)	20269.47	1.00
2	N. Scrubber #2 - Exhaust	10886.21	1.00
29	Auxiliary Solids Bldg. - With Permanganate (1)	7331.62	1.00
45	Auxiliary Bldg (2)	6937.71	1.00
37	Solids Bldg Fan #12	6812.94	1.00
46	Old Solids Bldg. (2)	6153.94	1.00
36	Old Solids Bldg.	6124.91	1.00
31	Auxiliary Solids Bldg - With Permanganate	4555.98	1.00
1	N. Scrubber #1 - Exhaust	4440.58	1.00
35	Central P. S. - Exhaust	4095.07	1.00
4	N. Scrubber #4 - Exhaust	3245.47	1.00
3	N. Scrubber #3 - Exhaust	2492.16	1.00
41	Total Primary Clarifiers	8272.14	1.00
8	N. Primary Effluent Channel	6581.46	1.00
53	Total Primary Effluent Channel (2)	5484.55	1.00
28	Auxiliary Solids Bldg - No Permanganate	1556.04	1.00
44	Total Aeration - Anoxic	4683.67	1.00
32	Auxiliary Solids Bldg - No Permanganate (2)	1177.55	1.00
7	S. Primary Clarifier #14	3463.00	1.00
51	Primary Effluent Channel - 1st 1/3	3290.73	1.00
43	Total Aeration - Aerobic	2608.55	1.00
42	Total Screw Pumps	2359.06	1.00
52	Primary Effluent Channel - 2nd 1/3	2193.82	1.00
50	Aeration Influent Channel	2164.27	1.00
40	Primary Clarifiers - Weir Area (Estimated)	1946.09	1.00
5	N. Primary Influent Channel	1737.93	1.00
22	S. Scrubber #1 - Exhaust	509.76	1.00
6	N. Primary Clarifier #16	1297.39	1.00
9	N. Primary Screw Pump	1189.16	1.00
10	S. Primary Screw Pump	1169.90	1.00
15	Aeration Basin (2) #8 - Anoxic	826.00	1.00
30	Old Grit Channel	587.36	1.00
25	N. Final Clarifier #7	554.31	1.00
17	Aeration Basin (2) #8 - Mid Aerobic	534.88	1.00
16	Aeration Basin (2) #8 - 1st Aerobic	519.15	1.00
23	N. Scrubber #4 - Exhaust (2)	102.66	1.00
21	S. Scrubber #2 - #3 - Exhaust (2)	91.76	1.00
18	Aeration Basin (2) #8 - Effluent	267.44	1.00
38	Centrate Channel	223.86	1.00
34	Dewatered Sludge	213.37	1.00
14	Aeration Basin (2) #8 - Influent	198.24	1.00
19	N. Aeration Mixed Liquor Channel	173.70	1.00
27	Thickener Building Exhaust	42.48	1.00
12	Aeration Basin #8 - Mid	125.85	1.00
13	Aeration Basin #8 - Effluent	125.85	1.00
24	N. Mixed Liquor Channel	98.18	1.00
11	Aeration Basin #8 - Influent	94.39	1.00
20	N. Aeration Mixed Liquor Channel (2)	60.42	1.00
33	Solids Wet Well	51.83	1.00
26	Thickened Solids Wet Well	18.52	1.00

Table 11
Average Transport Distances

Nashville - Metro Central

Location	Allowable	Stability Class 6 1 m/s Max/Dist	1	2 m/s Max/Dist	1	4 m/s Max/Dist	1	Stability Class 4 1 m/s Max/Dist	1	2 m/s Max/Dist	1	4 m/s Max/Dist	1
Total Bldg. (2)	0.462	4.647/1387	>2000	50.1/33	>2000	25.9/33	>2000	1.2/1258	>2000	243/33	>2000	25.9/33	1350
New Solids Bldg (2)	0.258	13.8/411	>2000	40/33	>2000	18.7/33	>2000	1.8/880	>2000	38.1/33	1410	18.7/33	810
Total North Scrubbers	0.447	1.5/886	>2000	1.1/700	>2000	.78/584	1420	.4/843	-	.66/421	820	.93/237	620
Total Bldg. (1)	0.325	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
N. Scrubber #2 - Exhaust	0.640	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Auxiliary Solids Bldg. - With Permanganate (1	0.477	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Auxiliary Bldg (2)	0.594	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Solids Bldg Fan #12	0.258	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Old Solids Bldg. (2)	0.389	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Old Solids Bldg.	0.390	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Auxiliary Solids Bldg - With Permanganate	0.372	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
N. Scrubber #1 - Exhaust	0.679	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Central P. S. - Exhaust	0.454	.28/920	-	.19/759	-	NR	NR	NR	NR	NR	NR	NR	NR
N. Scrubber #4 - Exhaust	0.224	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
N. Scrubber #3 - Exhaust	0.306	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Total Primary Clarifiers	0.612	2.7/90	810	1.4/90	450	.68/90	150	2.5/61	340	1.3/61	150	.63/61	70
N. Primary Effluent Channel	0.881	1.3/152	810	.64/152	390	.31/152	-	1.1/96	320	.55/96	150	.28/96	-
Total Primary Effluent Channel (2)	0.881	2.2/129	430	1.11/129	240	.56/129	-	2.2/67	220	1.1/67	120	NR	NR
Auxiliary Solids Bldg - No Permanganate	0.970	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Total Aeration - Anoxic	0.732	2.0/88	180	.98/88	90	NR	NR	1.2/88	120	NR	NR	NR	NR
Auxiliary Solids Bldg - No Permanganate (2)	1.429	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
S. Primary Clarifier #14	0.395	1.0/139	550	0.5/139	250	0.25/139	-	0.92/79	250	0.46/79	120	NR	NR
Primary Effluent Channel - 1st 1/3	0.881	2.1/117	360	1.1/117	160	.53/117	-	2.1/56	160	1.0/56	80	NR	NR
Total Aeration - Aerobic	0.259	1.1/88	80	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Total Screw Pumps	0.568	.32/284	-	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Primary Effluent Channel - 2nd 1/3	0.881	1/125	-	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Aeration Influent Channel	0.881	6.1/28	170	3.1/28	80	NR	NR	3.5/28	60	NR	NR	NR	NR
Primary Clarifiers - Weir Area (Estimated)	0.381	1.19/100	190	.59/100	280	.3/100	-	1.2/49	190	NR	NR	NR	NR
N. Primary Influent Channel	0.736	.43/116	-	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
S. Scrubber #1 - Exhaust	0.131	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
N. Primary Clarifier #16	0.466	.43/116	-	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
N. Primary Screw Pump	0.293	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
S. Primary Screw Pump	0.206	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Aeration Basin (2) #8 - Anoxic	0.755	1.25/41	80	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Old Grit Channel	0.245	.52/107	280	.26/107	80	NR	NR	.52/50	120	NR	NR	NR	NR
N. Final Clarifier #7	0.169	.088/165	-	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Aeration Basin (2) #8 - Mid Aerobic	0.361	1.11/33	90	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Aeration Basin (2) #8 - 1st Aerobic	0.547	1.1/33	70	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
N. Scrubber #4 - Exhaust (2)	0.249	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
S. Scrubber #2 - #3 - Exhaust (2)	0.966	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Aeration Basin (2) #8 - Effluent	0.067	.57/33	50	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Centrate Channel	0.442	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Dewatered Sludge	0.236	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Aeration Basin (2) #8 - Influent	0.892	0.24/47	-	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
N. Aeration Mixed Liquor Channel	0.142	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Thickener Building Exhaust	0.376	.01/446	-	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Aeration Basin #8 - Mid	0.175	0.15/47	-	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Aeration Basin #8 - Effluent	0.175	.15/47	-	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
N. Mixed Liquor Channel	0.316	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Aeration Basin #8 - Influent	0.224	.11/47	-	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
N. Aeration Mixed Liquor Channel (2)	0.215	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Solids Wet Well	0.637	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Thickened Solids Wet Well	0.241	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR

Table 12
Peak Transport Distances

Nashville - Metro Central

			Stability Class 6									Stability Class 4								
				1 m/s			2 m/s			4 m/s			1 m/s			2 m/s			4 m/s	
Location	Allowable	Allowable	Max/Dist	1	5	Max/Dist	1	5	Max/Dist	1	5	Max/Dist	1	5	Max/Dist	1	5	Max/Dist	1	5
Total Bldg. (2)	1	5	13.9/1387	>2000	>2000	1303/33	>2000	>2000	77.6/33	>2000	1980	3.7/1259	600	-	730/33	>2000	1310	77.6/33	>2000	750
New Solids Bldg (2)	1	5	42.4/411	>2000	>2000	117/33	>2000	>2000	57.8/33	>2000	1500	5.5/880	>2000	1110	117/33	>2000	1010	57.8/33	2000	590
Total North Scrubbers	1	5	4.6/886	>2000	-	3.3/700	>2000	-	2.5/584	1910	-	1.2/843	1310	-	2.1/421	1110	-	2.9/237	720	-
Total Bldg. (1)	1	5	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
N. Scrubber #2 - Exhaust	1	5	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Auxiliary Solids Bldg. - With Permanganate (1)	1	5	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Auxiliary Bldg (2)	1	5	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Solids Bldg Fan #12	1	5	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Old Solids Bldg. (2)	1	5	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Old Solids Bldg.	1	5	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Auxiliary Solids Bldg - With Permanganate	1	5	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
N. Scrubber #1 - Exhaust	1	5	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Central P. S. - Exhaust	1	5	.87/920	-	-	.59/759	-	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
N. Scrubber #4 - Exhaust	1	5	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
N. Scrubber #3 - Exhaust	1	5	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Total Primary Clarifiers	1	5	27.2/90	>2000	950	13.6/90	1830	550	6.8/90	1120	250	25.1/61	110	380	12.6/61	710	270	6.3/61	420	130
N. Primary Effluent Channel	1	5	12.8/152	>2000	650	6.4/152	1410	280	3.2/152	790	-	11.1/96	880	260	5.5/96	520	140	2.8/96	310	-
Total Primary Effluent Channel (2)	1	5	22.3/129	>2000	540	11.2/129	1410	430	5.6/129	870	180	21.3/67	820	320	10.6/67	570	180	5.3/67	350	80
Auxiliary Solids Bldg - No Permanganate	1	5	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Total Aeration - Anoxic	1	5	19.7/88	1810	340	9.8/88	1010	140	4.9/88	420	-	11.7/88	690	150	5.9/88	390	90	NR	NR	NR
Auxiliary Solids Bldg - No Permanganate (2)	1	5	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
S. Primary Clarifier #14	1	5	10.0/139	1610	450	5/139	950	139	2.5/139	550	-	9.2/79	610	180	4.6/79	380	-	NR	NR	NR
Primary Effluent Channel - 1st 1/3	1	5	21.2/117	1610	570	10.6/117	1020	370	5.3/117	650	120	21/56	650	230	10.5/56	420	170	5.2/56	250	70
Total Aeration - Aerobic	1	5	11/88	1110	150	5.5/88	520	90	NR	NR	NR	6.5/88	420	90	3.2/88	220	-	NR	NR	NR
Total Screw Pumps	1	5	3.2/284	1100	-	1.6/284	600	-	.8/284	-	-	3.5/127	480	-	1.7/127	290	-	NR	NR	NR
Primary Effluent Channel - 2nd 1/3	1	5	62/28	1210	370	31.1/28	750	130	15.6/28	420	80	35.2/28	480	150	17.6/28	310	60	NR	NR	NR
Aeration Influent Channel	1	5	61.5/28	1210	350	30.7/28	710	150	15.4/28	430	60	34.8/28	470	150	17.8/28	300	80	NR	NR	NR
Primary Clarifiers - Weir Area (Estimated)	1	5	11.9/100	1120	380	5.9/100	700	180	3.0/100	420	-	11.7/49	450	150	5.8/49	300	80	2.9/49	190	-
N. Primary Influent Channel	1	5	16.8/104	1190	380	8.4/104	680	240	4.2/104	410	-	16.9/48	410	150	8.5/48	290	110	4.2/48	180	-
S. Scrubber #1 - Exhaust	1	5	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
N. Primary Clarifier #16	1	5	4.3/116	800	-	2.1/116	420	-	1.1/116	130	-	4.0/66	310	-	2.0/66	80	-	NR	NR	NR
N. Primary Screw Pump	1	5	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
S. Primary Screw Pump	1	5	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Aeration Basin (2) #8 - Anoxic	1	5	12.5/41	550	130	6.3/41	210	90	3.1/41	80	-	7.1/41	210	70	3.6/41	100	-	NR	NR	NR
Old Grit Channel	1	5	5.2/107	510	110	2.6/110	310	-	1.3/107	120	-	5.2/50	210	70	2.6/50	150	-	NR	NR	NR
N. Final Clarifier #7	1	5	.88/165	-	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Aeration Basin (2) #8 - Mid Aerobic	1	5	11.5/33	400	80	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Aeration Basin (2) #8 - 1st Aerobic	1	5	11.0/33	350	80	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
N. Scrubber #4 - Exhaust (2)	1	5	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
S. Scrubber #2 - #3 - Exhaust (2)	1	5	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Aeration Basin (2) #8 - Effluent	1	5	5.6/33	150	50	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Centrate Channel	1	5	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Dewatered Sludge	1	5	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Aeration Basin (2) #8 - Influent	1	5	2.36/37	-	80	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
N. Aeration Mixed Liquor Channel	1	5	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Thickener Building Exhaust	1	5	.038/446	-	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Aeration Basin #8 - Mid	1	5	1.5/47	-	60	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Aeration Basin #8 - Effluent	1	5	1.5/47	-	60	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
N. Mixed Liquor Channel	1	5	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Aeration Basin #8 - Influent	1	5	1.1/47	-	510	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
N. Aeration Mixed Liquor Channel (2)	1	5	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Solids Wet Well	1	5	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Thickened Solids Wet Well	1	5	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR

Table 13
Required Percent Removals (Average)

Nashville - Metro Central

Sample #	Location	Distance (Feet)	Initial OER	Design Endpoints 5	Design Endpoints 1	Final OER 5	Final OER 1	Required % Removal 5	Required % Removal 1
49	Total Bldg. (2)	50	40299.03	2.308	0.462	1450	275	96%	99%
47	New Solids Bldg (2)	50	29178.66	1.289	0.258	600	125	98%	100%
39	Total North Scrubbers	80	7021.47	2.235	0.447	2100	700	70%	90%
48	Total Bldg. (1)		NR	NR	NR			NR	NR
2	N. Scrubber #2 - Exhaust		NR	NR	NR			NR	NR
29	Auxiliary Solids Bldg. - With Permanganate (1		NR	NR	NR			NR	NR
45	Auxiliary Bldg (2)		NR	NR	NR			NR	NR
37	Solids Bldg Fan #12		NR	NR	NR			NR	NR
46	Old Solids Bldg. (2)		NR	NR	NR			NR	NR
36	Old Solids Bldg.		NR	NR	NR			NR	NR
31	Auxiliary Solids Bldg - With Permanganate		NR	NR	NR			NR	NR
32	N. Scrubber #1 - Exhaust		NR	NR	NR			NR	NR
35	Central P. S. - Exhaust	80	BT	BT	BT			0%	0%
4	N. Scrubber #4 - Exhaust		NR	NR	NR			NR	NR
3	N. Scrubber #3 - Exhaust		NR	NR	NR			NR	NR
41	Total Primary Clarifiers	120	827.21	3.059	0.612	827.21	250	0%	70%
8	N. Primary Effluent Channel	120	658.15	4.404	0.881	658.15	215	0%	67%
53	Total Primary Effluent Channel (2)	120	548.46	4.404	0.881	548.46	215	0%	61%
28	Auxiliary Solids Bldg - No Permanganate		NR	NR	NR			NR	NR
44	Total Aeration - Anoxic	200	468.37	3.661	0.732	468.37	170	0%	64%
32	Auxiliary Solids Bldg - No Permanganate (2		NR	NR	NR			NR	NR
7	S. Primary Clarifier #14	120	346.30	1.977	0.395	346.3	135	0%	61%
51	Primary Effluent Channel - 1st 1/3	150	329.07	4.404	0.881	329.07	135	0%	59%
43	Total Aeration - Aerobic	100	260.85	1.293	0.259	260.85	65	0%	75%
42	Total Screw Pumps	80	BT	BT	BT			0%	0%
52	Primary Effluent Channel - 2nd 1/3	60	BT	BT	BT			0%	0%
50	Aeration Influent Channel	150	216.43	4.404	0.881	216.43	32	0%	85%
40	Primary Clarifiers - Weir Area (Estimated	80	194.61	1.903	0.381	194.61	62	0%	68%
5	N. Primary Influent Channel	120	BT	BT	BT			0%	0%
22	S. Scrubber #1 - Exhaust		NR	NR	NR			NR	NR
6	N. Primary Clarifier #16		BT	BT	BT			0%	0%
9	N. Primary Screw Pump		NR	NR	NR			NR	NR
10	S. Primary Screw Pump		NR	NR	NR			NR	NR
15	Aeration Basin (2) #8 - Anoxic	120	82.60	3.775	0.755	82.60	50.00	0%	39%
30	Old Grit Channel	120	58.74	1.224	0.245	58.74	30.00	0%	49%
25	N. Final Clarifier #7		BT	BT	BT			0%	0%
17	Aeration Basin (2) #8 - Mid Aerobic	200	53.49	1.804	0.361	53.49	17	0%	68%
16	Aeration Basin (2) #8 - 1st Aerobic	120	51.91	2.733	0.547	51.91	51.91	0%	0%
23	N. Scrubber #4 - Exhaust (2)		NR	NR	NR			NR	NR
21	S. Scrubber #2 - #3 - Exhaust (2)		NR	NR	NR			NR	NR
18	Aeration Basin (2) #8 - Effluent	120	26.74	0.336	0.067	26.74	26.74	0%	0%
38	Centrate Channel		NR	NR	NR			NR	NR
34	Dewatered Sludge		NR	NR	NR			NR	NR
14	Aeration Basin (2) #8 - Influent		BT	BT	BT			0%	0%
19	N. Aeration Mixed Liquor Channel		NR	NR	NR			NR	NR
27	Thickener Building Exhaust		BT	BT	BT			0%	0%
12	Aeration Basin #8 - Mid		BT	BT	BT			0%	0%
13	Aeration Basin #8 - Effluent		BT	BT	BT			0%	0%
24	N. Mixed Liquor Channel		NR	NR	NR			NR	NR
11	Aeration Basin #8 - Influent		BT	BT	BT			0%	0%
20	N. Aeration Mixed Liquor Channel (2)		NR	NR	NR			NR	NR
33	Solids Wet Well		NR	NR	NR			NR	NR
26	Thickened Solids Wet Well		NR	NR	NR			NR	NR

Table 14
Required Percent Removals (Peak)

Nashville - Metro Central

Sample #	Location	Distance (Feet)	Initial OER	Design Endpoint	Final OER	Required % Removal
49	Total Bldg. (2)	50	120897.10	1	80	100%
47	New Solids Bldg (2)	50	87535.99	1	500	99%
39	Total North Scrubbers	80	21064.42	1	500	98%
48	Total Bldg. (1)		NR	1		NR
2	N. Scrubber #2 - Exhaust		NR	1		NR
29	Auxiliary Solids Bldg. - With Permanganat		NR	1		NR
45	Auxiliary Bldg (2)		NR	1		NR
37	Solids Bldg Fan #12		NR	1		NR
46	Old Solids Bldg. (2)		NR	1		NR
36	Old Solids Bldg.		NR	1		NR
31	Auxiliary Solids Bldg - With Permanganate		NR	1		NR
32	N. Scrubber #1 - Exhaust		NR	1		NR
35	Central P. S. - Exhaust	80	BT	1		0%
4	N. Scrubber #4 - Exhaust		NR	1		NR
3	N. Scrubber #3 - Exhaust		NR	1		NR
41	Total Primary Clarifiers	120	8272.14	1	400	95%
8	N. Primary Effluent Channel	120	6581.46	1	245	96%
53	Total Primary Effluent Channel (2)	120	5484.55	1	245	96%
28	Auxiliary Solids Bldg - No Permanganate		NR	1		NR
44	Total Aeration - Anoxic	200	4683.67	1	240	95%
32	Auxiliary Solids Bldg - No Permanganate (		NR	1		NR
7	S. Primary Clarifier #14	120	3463.00	1	490	86%
51	Primary Effluent Channel - 1st 1/3	150	3290.73	1	155	95%
43	Total Aeration - Aerobic	100	2608.55	1	500	81%
42	Total Screw Pumps	80	2359.06	1	725	69%
52	Primary Effluent Channel - 2nd 1/3	60	2193.82	1	355	84%
50	Aeration Influent Channel	150	2164.27	1	85	96%
40	Primary Clarifiers - Weir Area (Estimated)	80	1946.09	1	165	92%
5	N. Primary Influent Channel	120	1737.93	1	103	94%
22	S. Scrubber #1 - Exhaust		NR	1		NR
6	N. Primary Clarifier #16		1297.39	1	305	76%
9	N. Primary Screw Pump		NR	1		NR
10	S. Primary Screw Pump		NR	1		NR
15	Aeration Basin (2) #8 - Anoxic	120	826.00	1	66	92%
30	Old Grit Channel	120	587.36	1	110	81%
25	N. Final Clarifier #7		BT	1		0%
17	Aeration Basin (2) #8 - Mid Aerobic	200	534.88	1	120	78%
16	Aeration Basin (2) #8 - 1st Aerobic	120	519.15	1	65	87%
23	N. Scrubber #4 - Exhaust (2)		NR	1		NR
21	S. Scrubber #2 - #3 - Exhaust (2)		NR	1		NR
18	Aeration Basin (2) #8 - Effluent	120	267.44	1	65	76%
38	Centrate Channel		NR	1		NR
34	Dewatered Sludge		NR	1		NR
14	Aeration Basin (2) #8 - Influent		BT	1		0%
19	N. Aeration Mixed Liquor Channel		NR	1		NR
27	Thickener Building Exhaust		BT	1		0%
12	Aeration Basin #8 - Mid		BT	1		0%
13	Aeration Basin #8 - Effluent		BT	1		0%
24	N. Mixed Liquor Channel		NR	1		NR
11	Aeration Basin #8 - Influent		BT	1		0%
20	N. Aeration Mixed Liquor Channel (2)		NR	1		NR
33	Solids Wet Well		NR	1		NR
26	Thickened Solids Wet Well		NR	1		NR

Table 15
Priority Odor Sources
Class 1

Nashville - Metro Central

Rank	Class 1 Sources Average	Rank	Class 1 Sources Peak
1	Total Bldg. (2)	1	Total Bldg. (2)
2	New Solids Bldg (2)	2	New Solids Bldg (2)
3	Total North Scrubbers	3	Total North Scrubbers
4	Total Primary Clarifiers	4	Total Primary Clarifiers
5	N. Primary Effluent Channel	5	N. Primary Effluent Channel
6	S. Primary Clarifier #14	6	Total Primary Effluent Channel (2)
7	Total Primary Effluent Channel (2)	7	Total Aeration - Anoxic
8	Primary Effluent Channel - 1st 1/3	8	S. Primary Clarifier #14
9	Old Grit Channel	9	Primary Effluent Channel - 1st 1/3
10	Primary Clarifiers - Weir Area (Estimated)	10	Primary Effluent Channel - 2nd 1/3
11	Total Aeration - Anoxic	11	Aeration Influent Channel
12	Aeration Influent Channel	12	N. Primary Influent Channel
13	Aeration Basin (2) #8 - Mid Aerobic	13	Primary Clarifiers - Weir Area (Estimated)
14	Total Aeration - Aerobic	15	Total Screw Pumps
15	Aeration Basin (2) #8 - Anoxic	16	N. Primary Clarifier #16
16	Aeration Basin (2) #8 - 1st Aerobic	17	Aeration Basin (2) #8 - Anoxic
17	Aeration Basin (2) #8 - Effluent	18	Old Grit Channel
		19	Aeration Basin (2) #8 - Mid Aerobic
		20	Aeration Basin (2) #8 - 1st Aerobic
		21	Aeration Basin (2) #8 - Effluent

Table 16
Priority of Odor Sources
Class 2

Nashville - Metro Central

Total Bldg. (2)
New Solids Bldg (2)
Total Bldg. (1)
Auxiliary Bldg (2)
Solids Bldg Fan #12
N. Scrubber #1 - Exhaust
Auxiliary Solids Bldg - With Permanganate
Old Solids Bldg. (2)
Old Solids Bldg.
Central P. S. - Exhaust
Total Primary Clarifiers
N. Primary Effluent Channel
N. Scrubber #3 - Exhaust
Total Primary Effluent Channel (2)
Total Aeration - Anoxic
Total Screw Pumps
S. Primary Clarifier #14
Primary Effluent Channel - 1st 1/3
Primary Clarifiers - Weir Area (Estimated)
Total Aeration - Aerobic
Primary Effluent Channel - 2nd 1/3
Aeration Influent Channel
Auxiliary Solids Bldg - No Permanganate
N. Primary Screw Pump
S. Primary Screw Pump
N. Primary Clarifier #16
Total North Scrubbers
N. Scrubber #2 - Exhaust
Auxiliary Solids Bldg. - With Permanganate (1)
N. Scrubber #4 - Exhaust

Odor Logs

Central WWTP GPS Data
K. Harrison
6/11/2002

Reference	Location	N	W
1	Scrubber Stack Grit Chambers 1 & 2	36 11.204	086 47.464
2	Scrubber Stack Grit Chambers 3&4	36 11.215	086 47.471
3	North Primary #16 Influent	36 11.218	086 47.499
4	North Primary #17 Influent	36 11.225	086 47.503
5	North Primary #18 Influent	36 11.231	086 47.507
6	North Primary #19 Influent	36 11.238	086 47.511
7	North Primary #20 Influent	36 11.245	086 47.516
8	North Primary #21 Influent	36 11.251	086 47.520
9	North Primary #16 Effluent	36 11.233	086 47.469
10	North Primary #17 Effluent	36 11.239	086 47.474
11	North Primary #18 Effluent	36 11.245	086 47.478
12	North Primary #19 Effluent	36 11.251	086 47.482
13	North Primary #20 Effluent	36 11.257	086 47.486
14	North Primary #21 Effluent	36 11.264	086 47.490
15	North Pri. Eff. Channel at Flume	36 11.190	086 47.439
16	North Pri. Eff. Channel at turn	36 11.167	086 47.423
17	Screw Pumps North Corner	36 11.193	086 47.379
18	Screw Pumps west corner	36 11.182	086 47.423
19	Screw Pumps south corner	36 11.174	086 47.410
20	Screw Pumps east corner	36 11.187	086 47.383
21	Aeration Basin #1	36 11.196	086 47.408
22	Aeration Basin #2	36 11.211	086 47.417
23	Aeration Basin #3	36 11.226	086 47.427
24	Aeration Basin #4	36 11.241	086 47.436
25	Aeration Basin #5	36 11.257	086 47.447
26	Aeration Basin #6	36 11.272	086 47.457
27	Aeration Basin #7	36 11.287	086 47.467
28	Aeration Basin #8	36 11.303	086 47.476
29	Final Clarifier #1	36 11.177	086 47.358
30	Final Clarifier #2	36 11.151	086 47.341
31	Final Clarifier #3	36 11.191	086 47.326
32	Final Clarifier #4	36 11.165	086 47.308
33	Final Clarifier #5		
34	Final Clarifier #6		
35	Final Clarifier #7	36 11.327	086 47.441
36	Final Clarifier #8	36 11.300	086 47.423
37	Final Clarifier #9	36 11.276	086 47.407
38	Final Clarifier #10	36 11.241	086 47.383
39	Final Clarifier #11	36 11.212	086 47.366
40	Final Clarifier #12	36 11.341	086 47.407
41	Final Clarifier #13	36 11.315	086 47.391
42	Final Clarifier #14	36 11.229	086 47.334
43	South Primary Inf. Channel	36 11.159	086 47.411
44	South Primary #1 Influent	36 11.066	086 47.353
45	South Primary #15 Influent	36 11.155	086 47.408

46	South Primary #1 Effluent	36 11.079	086 47.323
47	South Primary #15 Effluent	36 11.166	086 47.380
48	South Primary Eff. Channel at Clar #1	36 11.076	086 47.321
49	South Primary Eff Channel at flume	36 11.178	086 47.387
50	Effluent Flume	36 11.159	086 47.228
51	Center Main Press Bldg (Incinerator Bldg)	36 11.066	086 47.245
52	Center Small Press Bldg (Ash Bldg)	36 11.035	086 47.246
53	Sludge Loading Chute	36 11.073	086 47.229

Notes: Scrubber stacks read at ground elevation on east side of scrubber

Central WWTP Odor Log Data
K. Harrison
6/11/2002

Date	Time	Location	N	W
2/5/2001	4:45 PM	1306 6th Ave North	36 10.610	086 47.433
2/6/2001	7:10 AM	2214 MetroCenter Blvd	36 11.627	086 48.108
2/7/2001	7:15 AM	Exxon - MetroCenter Blvd	36 11.305	086 47.871
2/8/2001	7:00 AM	I-65 & Cumberland River	36 11.498	086 47.050
2/8/2001	7:05 AM	Exxon - MetroCenter Blvd	36 11.305	086 47.871
2/13/2001	11:30 AM	2214 MetroCenter Blvd	36 11.627	086 48.108
2/13/2001	5:15 PM	2214 MetroCenter Blvd	36 11.627	086 48.108
2/14/2001	7:40 AM	2214 MetroCenter Blvd	36 11.627	086 48.108
2/15/2001	12:00 PM	2214 MetroCenter Blvd	36 11.627	086 48.108
3/20/2001	6:55 PM	1306 6th Ave North	36 10.610	086 47.433
4/2/2001	7:15 AM	2214 MetroCenter Blvd	36 11.627	086 48.108
4/2/2001	4:10 PM	2214 MetroCenter Blvd	36 11.627	086 48.108
4/3/2001	8:05 AM	2214 MetroCenter Blvd	36 11.627	086 48.108
4/3/2001	1:30 PM	8th & I-65	36 11.000	086 47.870
4/24/2001	3:30 PM	3rd & Garfield	36 11.004	086 47.403
4/26/2001	9:30 AM	1306 6th Ave North	36 10.610	086 47.433
5/31/2001	8:00 AM	2214 MetroCenter Blvd	36 11.627	086 48.108
10/11/2001	3:50 PM	2214 MetroCenter Blvd	36 11.627	086 48.108
11/7/2001	10:35 PM	1224 6th Ave North	36 10.547	086 47.393
11/9/2001	7:40 PM	1224 6th Ave North	36 10.547	086 47.393
11/11/2001	4:25 PM	1224 6th Ave North	36 10.547	086 47.393
11/21/2001	6:45 PM	1224 6th Ave North	36 10.547	086 47.393

Scrubber O&M Costs

Scrubber Design
by
Huber Environmental, Inc.

Facility Information -		Nashville - Central	
Location		North Grit and Primary Influent Chai	
Concentration		100	
Run Date -		4/29/2003	

Input Data

Selection of Parameters		(Use y for true, n for false)			**L'**	**G'**	**HTU/3.5**	**HTU/2**
NH_3	*n*	*Acid Scrubber Not Required*			*1024*	*492*	7	*6*
Mercapt*	*n*	*No Alkaline Scrubbing Required*			*5004*	*500*	32.2	*28*
H_2S	*y*	*Alkaline Scrubbing Will Be Required*			*1331*	*1229*	22	*19.4*

Recirculation Rates

Diameter	**GPM**
2	20
3	46
4	82
5	126
6	185
7	250
8	326
9	415
10	510
11	620
12	735

Safety Factor (%)		*20%*	**Oxidation**	
Stages	**(Acid)**		**None**	
Stages	**(Alkaline)**	*2*	**Partial**	
	Total	*2*	**Full**	**y**

Parameter Data

Parameter	Mole Weight	I - Conc (Avg)	I - Conc (Peak)	O - Conc (Avg)	O - Conc (Peak)	% Rem (Avg)	% Rem (Peak)
H_2S	*34*	*100*	*200*	*0.1*	*0.2*	*99.90%*	*99.90%*
Mercapt*	*62*					*0.00%*	*0.00%*
NH_3	*17*					*0.00%*	*0.00%*

* Add Molecular Weigh

Inlet Air Data

ACFM	Temp (F)	Air Density	CO_2	CO_2 Corr.	External Loss	Loss/Stage
27000	*68*	*0.075*			*6*	*6*

Scrubbing Chemicals Data

Chemical	Mol. Wt	Sp. Gr	Conc. Factor	H_2S	Mercap	NH_3	Storage
A - NaOH	*40*	*10*	*25%*	*2.4*	*0.65*		*30*
B - NaOCl	*74.4*	*7.83*	*12.5%*	*8.9*	*3.6*		*30*
C - H_2SO_4	*98*	*8*	*93%*			*2.88*	*30*

Cost Data

	Electrical	A	B	C	Labor
	$0.035	*$0.45*	*$0.73*	*$1.00*	*$1.00*

Scrubber Design

Acid Stage		**Skip This Section**							
Gas #/Hr	Velocity	Tank Dia	Adj. Tk Dia.	Adj. Vel	Tank Area	NOG(Req)	Packing Size	Flow Rate	L'
121500		*0.00*		*0.00*	*0.00*	*0.00*			*0*
Des. Flow	L	L(Cor)	G'	Des Air	G	G(Cor)	HTU	HTU(Cor)	Z(Req)
0.00	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.000*	*0.00*
Z(Fin)	Depth/Stage	Set Depth	Z (Tot)	NOG(Fin)	NOG(1)	NOG(2)			
0.00	*0.00*		*0*	*0.00*	0.00	0.00			

Scrubber Design
by
Huber Environmental, Inc.

Alkaline Stage(s)												
Mercaptan		**Skip This Section and Go To H2S**										
Gas #/Hr	Velocity	Tank Dia	Adj. Tk Dia.	Final Tank Dia.	Final Velocity	Tank Area	NOG(Req)	Packing Size	Flow Rate			
121500.0	*500.00*	*0.00*		*8.0*	*0.00*	*50.24*	*0.00*					
L'	Des. Flow	L	L(Cor)	G'	Des Air	G	G(Cor)	HTU	HTU(Cor)			
0	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*			
Z(Req)	Z(Fin)	Depth/Stage	Set Depth	Z(Prelim)	Z(Final)	NOG(Fin)	NOG(1)	NOG(2)				
0.00	*0.00*	*0.00*		*0*	*0*	*0.00*	*0.00*	*0.00*				
H_2S												
Gas #/Hr	Velocity	Tank Dia	Adj. Tk Dia.	Final Tank Dia.	Final Velocity	Tank Area	NOG(Req)	Packing Size	Flow Rate			
121500.00	*500.00*	*8.29*	*8.00*	*8.00*	*537.42*	*50.24*	*6.91*	*3.50*	*326.0*			
Des. Flow	L	L(Cor)	G'	Des Air	G	G(Cor)	HTU	HTU(Cor)	Z(Req)			
133.63	*3247.02*	*0.74*	*1229.00*	*13721.10*	*2418.39*	*1.14*	*1.83*	*1.56*	*10.76*			
L'	Z(Fin)	Depth/Stage	Set Depth	Z(Prelim)	Z(Final)	NOG(Fin)	NOG(1)	NOG(2)				
1331.00	*12.92*	*6.46*	*10.00*	*20*	*20*	*12.83*	*6.42*	*6.42*				
Final												
Acid												
Tank Dia	Tank Area	Velocity	*Z*	Flow Rate	*Stages*							
0.00	*0.00*	*0.00*	*0*	*0*	*0*							
Alkaline												
Tank Dia	Tank Area	Velocity	*Z*	Flow Rate	Stages							
8.00	*50.24*	*537.42*	*20*	*326*	*2*							
NH3												
					Average							
		Stage 1			Stage 2				Total			
Inlet	Outlet	Lbs/Hr	% Removal	Inlet	Outlet	Lbs/Hr	% Removal	Lbs/Hr	% Removal	% Removal (Corr.)		
0.00	*0.00*	*0.00*	*0.00%*	*0.00*	*0.00*	*0.00*	*0.00%*	*0.00*	*0.00%*	*0.00%*		
					Peak							
		Stage 1			Stage 2				Total			
Inlet	Outlet	Lbs/Hr	% Removal	Inlet	Outlet	Lbs/Hr	% Removal	Lbs/Hr	% Removal	% Removal (Corr.)		
0.00	*0.00*	*0.00*	*0.00%*	*0.00*	*0.00*	*0.00*	*0.00%*	*0.00*	*0.00%*	*0.00%*		
H_2S												
					Average							
		Stage 1			Stage 2				Total			
Inlet	Outlet	Lbs/Hr	% Removal	Inlet	Outlet	Lbs/Hr	% Removal	Lbs/Hr	% Removal	% Removal (Corr.)		
100.00	*0.16*	*14.27*	*99.84%*	*0.16*	*0.00*	*0.00*	*99.84%*	*14.27*	*100.00%*	*99.90%*		
					Peak							
		Stage 1			Stage 2				Total			
Inlet	Outlet	Lbs/Hr	% Removal	Inlet	Outlet	Lbs/Hr	% Removal	Lbs/Hr	% Removal	% Removal (Corr.)		
200.00	*0.33*	*28.55*	*99.84%*	*0.33*	*0.00*	*0.05*	*99.84%*	*28.59*	*100.00%*	*99.90%*		
Mercaptan												
					Average							
		Stage 1			Stage 2				Total			
Inlet	Outlet	Lbs/Hr	% Removal	Inlet	Outlet	Lbs/Hr	% Removal	Lbs/Hr	% Removal	% Removal (Corr.)		
0.00	*0.00*	*0.00*	0.00%	*0.00*	*0.00*	*0.00*	*0.00%*	*0.00*	*0.00%*	*0.00%*		
					Peak							
		Stage 1			Stage 2				Total			
Inlet	Outlet	Lbs/Hr	% Removal	Inlet	Outlet	Lbs/Hr	% Removal	Lbs/Hr	% Removal	% Removal (Corr.)		
0.00	*0.00*	*0.00*	0.00%	*0.00*	*0.00*	*0.00*	0.00%	*0.00*	*0.00%*	*0.00%*		

Scrubber Design
by
Huber Environmental, Inc.

Output Data

Chemical Usage

Acid

Average

	Stage 1		Stage 2		Total	
	Lbs/Hr	Gal/Hr	Lbs/Hr	Gal/Hr	Gal/Hr	Gal/Day
H_2SO_4	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*

Peak

	Stage 1		Stage 2		Total	
	Lbs/Hr	Gal/Hr	Lbs/Hr	Gal/Hr	Gal/Hr	Gal/Day
H_2SO_4	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*

Alkaline

Average

	Stage 1		Stage 2		Total	
	Lbs/Hr	Gal/Hr	Lbs/Hr	Gal/Hr	Gal/Hr	Gal/Day
NaOH	*34.26*	*13.70*	*0.00*	*0.00*	*13.70*	*328.85*
NaOCl	*127.03*	*129.79*	*0.00*	*0.00*	*129.79*	*3114.94*

Peak

	Stage 1		Stage 2		Total	
	Lbs/Hr	Gal/Hr	Lbs/Hr	Gal/Hr	Gal/Hr	Gal/Day
NaOH	*68.51*	*27.40*	*0.11*	*0.04*	*27.45*	*658.78*
NaOCl	*254.06*	*259.58*	*0.42*	*0.42*	*260.00*	*6240.06*

Metering Pumps

	Stage 1		Stage 2	
	Gals/Hr	GPM	Gals/Hr	GPM
NaOH	*27.40*	*0.46*	*0.04*	*0.00*
NaOCl	*259.58*	*4.33*	*0.42*	*0.01*
H_2SO_4	*0.00*	*0.00*	*0.00*	*0.00*

Chemical Storage Tanks		**Blowdown Rate**			
			Amount	Solubility	GPM
NaOH	*9866*	NH_4SO_4	*0.00*	*71.00*	*0.00*
NaOCl	*93448*	NaCl	*98.48*	*36.00*	*1.64*
H_2SO_4	*0*	Na_2SO_4	*59.95*	*19.00*	*1.89*
		Evaporation	*10.00*		*4.50*
		Total			*8.03*

Operating Costs

Electrical

	Fan	Recirculation Pumps				Chemical Metering Pumps			
		Acid		Alkaline		Acid		Alkaline	
		Stage 1	Stage 2	Stage 1	Stage 2	Stage 1	Stage 2	Stage 1	Stage 2
HP	*57.35*	*0.00*	*0.00*	*9.80*	*9.80*	*0*	*0.00*	*0.50*	*0.50*
Adjusted HP	*60.00*			*10.00*	*10.00*			*0.50*	*0.50*
Kw-Hrs	*1074.24*	*0.00*	*0.00*	*179.04*	*179.04*	*0.00*	*0.00*	*8.95*	*8.95*
Cost	*$38*	*$0*	*$0*	*$6*	*$6*	*$0*	*$0*	*$0*	*$0*

Chemicals

	Acid		Alkaline			
	Stage 1	Stage 2	Stage 1		Stage 2	
			NaOH	NaOCl	NaOH	NaOCl
lbs/hr	*0.00*	*0.00*	*34.26*	*127.03*	*0.00*	*0.00*
Cost/day	*$0*	*$0*	*$372*	*$2,226*	*$0.00*	*$0.00*

Annual Cost

Labor	*$27,000*
Electrical	*$18,527*
Chemicals	*$947,975*
Total	*$993,502*

Scrubber Design

by

Huber Environmental, Inc.

Facility Information -		Nashville - Central							
Location		North Grit and Primary Influent Char							
Concentration		148							
Run Date -		4/29/2003							
					Input Data				
Selection of Parameters		(Use y for true, n for false)			**L'**	**G'**	**HTU/3.5**	**HTU/2**	
NH_3	*n*	*Acid Scrubber Not Required*			*1024*	*492*	7	*6*	
Mercapt*	*n*	*No Alkaline Scrubbing Required*			*5004*	*500*	32.2	*28*	
H_2S	*y*	*Alkaline Scrubbing Will Be Required*			*1331*	*1229*	22	*19.4*	
Recirculation Rates									
Diameter	**GPM**								
2	20								
3	46								
4	82								
5	126								
6	185								
7	250								
8	326								
9	415								
10	510								
11	620								
12	735								
Safety Factor (%)		*20%*	**Oxidation**						
Stages	**(Acid)**		**None**	**y**					
Stages	**(Alkaline)**	*1*	**Partial**						
	Total	***1***	**Full**						
Parameter Data									
Parameter	Mole Weight	I - Conc (Avg)	I - Conc (Peak)	O - Conc (Avg)	O - Conc (Peak)	% Rem (Avg)	% Rem (Peak)		
H_2S	*34*	*148*	*200*	*10*	*10*	*93.24%*	*95.00%*		
Mercapt*	*62*					*0.00%*	*0.00%*		
NH_3	*17*					*0.00%*	*0.00%*		
* Add Molecular Weigh									
Inlet Air Data									
ACFM	Temp (F)	Air Density	CO_2	CO_2 Corr.	External Loss	Loss/Stage			
18,000	*68*	*0.075*			*6*	*6*			
Scrubbing Chemicals Data									
Chemical	Mol. Wt	Sp. Gr	Conc. Factor	H_2S	Mercap	NH_3	Storage		
A - NaOH	*40*	*10*	*25%*	*2.4*	*0.65*		*30*		
B - NaOCl	*74.4*	*7.83*	*12.5%*	*0*	*0*		*30*		
C - H_2SO_4	*98*	*8*	*93%*			*2.88*	*30*		
Cost Data									
	Electrical	A	B	C	Labor				
	$0.035	*$0.45*	*$0.73*	*$1.00*	*$1.00*				
					Scrubber Design				
Acid Stage		**Skip This Section**							
Gas #/Hr	Velocity	Tank Dia	Adj. Tk Dia.	Adj. Vel	Tank Area	NOG(Req)	Packing Size	Flow Rate	L'
81000		*0.00*		*0.00*	*0.00*	*0.00*			*0*
Des. Flow	L	L(Cor)	G'	Des Air	G	G(Cor)	HTU	HTU(Cor)	Z(Req)
0.00	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.000*	*0.00*
Z(Fin)	Depth/Stage	Set Depth	Z (Tot)	NOG(Fin)	NOG(1)	NOG(2)			
0.00	*0.00*		*0*	*0.00*	0.00	0.00			

Scrubber Design
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Alkaline Stage(s)													
Mercaptan		**Skip This Section and Go To H2S**											
Gas #/Hr	Velocity	Tank Dia	Adj. Tk Dia.	Final Tank Dia.	Final Velocity	Tank Area	NOG(Req)	Packing Size	Flow Rate				
81000.0	500.00	0.00		7.0	0.00	38.47	0.00						
L'	Des. Flow	L	L(Cor)	G'	Des Air	G	G(Cor)	HTU	HTU(Cor)				
0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00				
Z(Req)	Z(Fin)	Depth/Stage	Set Depth	Z(Prelim)	Z(Final)	NOG(Fin)	NOG(1)	NOG(2)					
0.00	0.00	0.00		0	0	0.00	0.00	0.00					
H_2S													
Gas #/Hr	Velocity	Tank Dia	Adj. Tk Dia.	Final Tank Dia.	Final Velocity	Tank Area	NOG(Req)	Packing Size	Flow Rate				
81000.00	500.00	6.77	7.00	7.00	467.96	38.47	3.00	3.50	250.0				
Des. Flow	L	L(Cor)	G'	Des Air	G	G(Cor)	HTU	HTU(Cor)	Z(Req)				
102.31	3252.31	0.74	1229.00	10505.22	2105.81	1.11	1.83	1.52	4.54				
L'	Z(Fin)	Depth/Stage	Set Depth	Z(Prelim)	Z(Final)	NOG(Fin)	NOG(1)	NOG(2)					
1331.00	5.45	5.45	6.00	6	6	3.96	3.96	0.00					
Final													
Acid													
Tank Dia	Tank Area	Velocity	Z	Flow Rate	Stages								
0.00	0.00	0.00	0	0	0								
Alkaline													
Tank Dia	Tank Area	Velocity	Z	Flow Rate	Stages								
7.00	38.47	467.96	6	250	1								
NH3													
					Average								
		Stage 1			Stage 2				Total				
Inlet	Outlet	Lbs/Hr	% Removal	Inlet	Outlet	Lbs/Hr	% Removal	Lbs/Hr	% Removal	% Removal (Corr.)			
0.00	0.00	0.00	0.00%	0.00	0.00	0.00	0.00%	0.00	0.00%	0.00%			
					Peak								
		Stage 1			Stage 2				Total				
Inlet	Outlet	Lbs/Hr	% Removal	Inlet	Outlet	Lbs/Hr	% Removal	Lbs/Hr	% Removal	% Removal (Corr.)			
0.00	0.00	0.00	0.00%	0.00	0.00	0.00	0.00%	0.00	0.00%	0.00%			
H_2S													
					Average								
		Stage 1			Stage 2				Total				
Inlet	Outlet	Lbs/Hr	% Removal	Inlet	Outlet	Lbs/Hr	% Removal	Lbs/Hr	% Removal	% Removal (Corr.)			
148.00	2.82	13.84	98.09%	0.00	0.00	0.00	0.00%	13.84	98.09%	98.09%			
					Peak								
		Stage 1			Stage 2				Total				
Inlet	Outlet	Lbs/Hr	% Removal	Inlet	Outlet	Lbs/Hr	% Removal	Lbs/Hr	% Removal	% Removal (Corr.)			
200.00	3.81	18.70	98.09%	0.00	0.00	0.00	0.00%	18.70	98.09%	98.09%			
Mercaptan													
					Average								
		Stage 1			Stage 2				Total				
Inlet	Outlet	Lbs/Hr	% Removal	Inlet	Outlet	Lbs/Hr	% Removal	Lbs/Hr	% Removal	% Removal (Corr.)			
0.00	0.00	0.00	0.00%	0.00	0.00	0.00	0.00%	0.00	0.00%	0.00%			
					Peak								
		Stage 1			Stage 2				Total				
Inlet	Outlet	Lbs/Hr	% Removal	Inlet	Outlet	Lbs/Hr	% Removal	Lbs/Hr	% Removal	% Removal (Corr.)			
0.00	0.00	0.00	0.00%	0.00	0.00	0.00	0.00%	0.00	0.00%	0.00%			

Scrubber Design
by
Huber Environmental, Inc.

Output Data

Chemical Usage

Acid

	Average					
	Stage 1		Stage 2		Total	
	Lbs/Hr	Gal/Hr	Lbs/Hr	Gal/Hr	Gal/Hr	Gal/Day
H_2SO_4	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*

	Peak					
	Stage 1		Stage 2		Total	
	Lbs/Hr	Gal/Hr	Lbs/Hr	Gal/Hr	Gal/Hr	Gal/Day
H_2SO_4	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*

Alkaline

	Average					
	Stage 1		Stage 2		Total	
	Lbs/Hr	Gal/Hr	Lbs/Hr	Gal/Hr	Gal/Hr	Gal/Day
NaOH	*33.21*	*13.28*	*0.00*	*0.00*	*13.28*	*318.81*
NaOCl	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*

	Peak					
	Stage 1		Stage 2		Total	
	Lbs/Hr	Gal/Hr	Lbs/Hr	Gal/Hr	Gal/Hr	Gal/Day
NaOH	*44.88*	*17.95*	*0.00*	*0.00*	*17.95*	*430.82*
NaOCl	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*

Metering Pumps

	Stage 1		Stage 2	
	Gals/Hr	GPM	Gals/Hr	GPM
NaOH	*17.95*	*0.30*	*0.00*	*0.00*
NaOCl	*0.00*	*0.00*	*0.00*	*0.00*
H_2SO_4	*0.00*	*0.00*	*0.00*	*0.00*

Chemical Storage Tanks		**Blowdown Rate**			
			Amount	Solubility	GPM
NaOH	*9564*	NH_4SO_4	*0.00*	*71.00*	*0.00*
NaOCl	*0*	NaCl	*95.48*	*36.00*	*1.59*
H_2SO_4	*0*	Na_2SO_4	*58.12*	*19.00*	*1.83*
		Evaporation	*10.00*		*3.00*
		Total			*6.42*

Operating Costs

Electrical

	Fan	Recirculation Pumps				Chemical Metering Pumps			
		Acid		Alkaline		Acid		Alkaline	
		Stage 1	Stage 2	Stage 1	Stage 2	Stage 1	Stage 2	Stage 1	Stage 2
HP	*25.49*	*0.00*	*0.00*	*7.52*	*0.00*	*0*	*0.00*	*0.50*	*0.00*
Adjusted HP	*30.00*			*10.00*				*0.50*	
Kw-Hrs	*537.12*	*0.00*	*0.00*	*179.04*	*0.00*	*0.00*	*0.00*	*8.95*	*0.00*
Cost	*$19*	*$0*	*$0*	*$6*	*$0*	*$0*	*$0*	*$0*	*$0*

Chemicals

	Acid		Alkaline			
			Stage 1		Stage 2	
	Stage 1	Stage 2	NaOH	NaOCl	NaOH	NaOCl
lbs/hr	*0.00*	*0.00*	*33.21*	*0.00*	*0.00*	*0.00*
Cost/day	*$0*	*$0*	*$360*	*$0*	*$0.00*	*$0.00*

Annual Cost

Labor	*$18,000*
Electrical	*$9,263*
Chemicals	*$131,492*
Total	*$158,755*

Scrubber Design
by
Huber Environmental, Inc.

Facility Information -		Nashville - Central						
Location		Alternative 3 ®						
Concentration		8						
Run Date -		4/29/2003						

Input Data

Selection of Parameters		(Use y for true, n for false)	**L'**	**G'**	**HTU/3.5**	**HTU/2**
NH_3	*n*	*Acid Scrubber Not Required*	*1024*	*492*	7	*6*
Mercapt*	*n*	*No Alkaline Scrubbing Required*	*5004*	*500*	32.2	*28*
H_2S	*y*	*Alkaline Scrubbing Will Be Required*	*1331*	*1229*	22	*19.4*

Recirculation Rates

Diameter	**GPM**
2	20
3	46
4	82
5	126
6	185
7	250
8	326
9	415
10	510
11	620
12	735

Safety Factor (%)		*20%*	**Oxidation**	
Stages	**(Acid)**		**None**	
Stages	**(Alkaline)**	*1*	**Partial**	
	Total	***1***	**Full**	**y**

Parameter Data

Parameter	Mole Weight	I - Conc (Avg)	I - Conc (Peak)	O - Conc (Avg)	O - Conc (Peak)	% Rem (Avg)	% Rem (Peak)
H_2S	*34*	*8*	*8*	*0.1*	*0.1*	*98.75%*	*98.75%*
Mercapt*	*62*					*0.00%*	*0.00%*
NH_3	*17*					*0.00%*	*0.00%*

* Add Molecular Weigh

Inlet Air Data

ACFM	Temp (F)	Air Density	CO_2	CO_2 Corr.	External Loss	Loss/Stage
42,000	*68*	*0.075*			*6*	*6*

Scrubbing Chemicals Data

Chemical	Mol. Wt	Sp. Gr	Conc. Factor	H_2S	Mercap	NH_3	Storage
A - NaOH	*40*	*10*	*25%*	*2.4*	*0.65*		*30*
B - NaOCl	*74.4*	*7.83*	*12.5%*	*8.9*	*3.6*		*30*
C - H_2SO_4	*98*	*8*	*93%*			*2.88*	*30*

Cost Data

	Electrical	A	B	C	Labor
	$0.035	*$0.45*	*$0.73*	*$1.00*	*$1.00*

Scrubber Design

Acid Stage		**Skip This Section**							
Gas #/Hr	Velocity	Tank Dia	Adj. Tk Dia.	Adj. Vel	Tank Area	NOG(Req)	Packing Size	Flow Rate	L'
189000		*0.00*		*0.00*	*0.00*	*0.00*			*0*
Des. Flow	L	L(Cor)	G'	Des Air	G	G(Cor)	HTU	HTU(Cor)	Z(Req)
0.00	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.000*	*0.00*
Z(Fin)	Depth/Stage	Set Depth	Z (Tot)	NOG(Fin)	NOG(1)	NOG(2)			
0.00	*0.00*		*0*	*0.00*	0.00	0.00			

Scrubber Design
by
Huber Environmental, Inc.

Alkaline Stage(s)												
Mercaptan		**Skip This Section and Go To H2S**										
Gas #/Hr	Velocity	Tank Dia	Adj. Tk Dia.	Final Tank Dia.	Final Velocity	Tank Area	NOG(Req)	Packing Size	Flow Rate			
189000.0	*500.00*	*0.00*		*11.0*	*0.00*	*94.99*	*0.00*					
L'	Des. Flow	L	L(Cor)	G'	Des Air	G	G(Cor)	HTU	HTU(Cor)			
0	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*			
Z(Req)	Z(Fin)	Depth/Stage	Set Depth	Z(Prelim)	Z(Final)	NOG(Fin)	NOG(1)	NOG(2)				
0.00	*0.00*	*0.00*		*0*	*0*	*0.00*	*0.00*	*0.00*				
H_2S												
Gas #/Hr	Velocity	Tank Dia	Adj. Tk Dia.	Final Tank Dia.	Final Velocity	Tank Area	NOG(Req)	Packing Size	Flow Rate			
189000.00	*500.00*	*10.34*	*11.00*	*11.00*	*442.18*	*94.99*	*4.38*	*3.50*	*620.0*			
Des. Flow	L	L(Cor)	G'	Des Air	G	G(Cor)	HTU	HTU(Cor)	Z(Req)			
252.65	*3266.28*	*0.74*	*1229.00*	*25941.46*	*1989.79*	*1.10*	*1.83*	*1.50*	*6.55*			
L'	Z(Fin)	Depth/Stage	Set Depth	Z(Prelim)	Z(Final)	NOG(Fin)	NOG(1)	NOG(2)				
1331.00	*7.87*	*7.87*	*10.00*	*10*	*10*	*6.69*	*6.69*	*0.00*				
Final												
Acid												
Tank Dia	Tank Area	Velocity	*Z*	Flow Rate	*Stages*							
0.00	*0.00*	*0.00*	*0*	*0*	*0*							
Alkaline												
Tank Dia	Tank Area	Velocity	*Z*	Flow Rate	Stages							
11.00	*94.99*	*442.18*	*10*	*620*	*1*							
NH3												
					Average							
		Stage 1			Stage 2				Total			
Inlet	Outlet	Lbs/Hr	% Removal	Inlet	Outlet	Lbs/Hr	% Removal	Lbs/Hr	% Removal	% Removal (Corr.)		
0.00	*0.00*	*0.00*	*0.00%*	*0.00*	*0.00*	*0.00*	*0.00%*	*0.00*	*0.00%*	*0.00%*		
					Peak							
		Stage 1			Stage 2				Total			
Inlet	Outlet	Lbs/Hr	% Removal	Inlet	Outlet	Lbs/Hr	% Removal	Lbs/Hr	% Removal	% Removal (Corr.)		
0.00	*0.00*	*0.00*	*0.00%*	*0.00*	*0.00*	*0.00*	*0.00%*	*0.00*	*0.00%*	*0.00%*		
H_2S												
					Average							
		Stage 1			Stage 2				Total			
Inlet	Outlet	Lbs/Hr	% Removal	Inlet	Outlet	Lbs/Hr	% Removal	Lbs/Hr	% Removal	% Removal (Corr.)		
8.00	*0.01*	*1.78*	*99.88%*	*0.00*	*0.00*	*0.00*	*0.00%*	*1.78*	*99.88%*	*99.88%*		
					Peak							
		Stage 1			Stage 2				Total			
Inlet	Outlet	Lbs/Hr	% Removal	Inlet	Outlet	Lbs/Hr	% Removal	Lbs/Hr	% Removal	% Removal (Corr.)		
8.00	*0.01*	*1.78*	*99.88%*	*0.00*	*0.00*	*0.00*	*0.00%*	*1.78*	*99.88%*	*99.88%*		
Mercaptan												
					Average							
		Stage 1			Stage 2				Total			
Inlet	Outlet	Lbs/Hr	% Removal	Inlet	Outlet	Lbs/Hr	% Removal	Lbs/Hr	% Removal	% Removal (Corr.)		
0.00	*0.00*	*0.00*	0.00%	*0.00*	*0.00*	*0.00*	*0.00%*	*0.00*	*0.00%*	*0.00%*		
					Peak							
		Stage 1			Stage 2				Total			
Inlet	Outlet	Lbs/Hr	% Removal	Inlet	Outlet	Lbs/Hr	% Removal	Lbs/Hr	% Removal	% Removal (Corr.)		
0.00	*0.00*	*0.00*	0.00%	*0.00*	*0.00*	*0.00*	0.00%	*0.00*	*0.00%*	*0.00%*		

Scrubber Design
by
Huber Environmental, Inc.

Output Data

Chemical Usage

Acid

	Average					
	Stage 1		Stage 2		Total	
	Lbs/Hr	Gal/Hr	Lbs/Hr	Gal/Hr	Gal/Hr	Gal/Day
H_2SO_4	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*

	Peak					
	Stage 1		Stage 2		Total	
	Lbs/Hr	Gal/Hr	Lbs/Hr	Gal/Hr	Gal/Hr	Gal/Day
H_2SO_4	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*

Alkaline

	Average					
	Stage 1		Stage 2		Total	
	Lbs/Hr	Gal/Hr	Lbs/Hr	Gal/Hr	Gal/Hr	Gal/Day
NaOH	*4.26*	*1.71*	*0.00*	*0.00*	*1.71*	*40.94*
NaOCl	*15.81*	*16.16*	*0.00*	*0.00*	*16.16*	*387.79*

	Peak					
	Stage 1		Stage 2		Total	
	Lbs/Hr	Gal/Hr	Lbs/Hr	Gal/Hr	Gal/Hr	Gal/Day
NaOH	*4.26*	*1.71*	*0.00*	*0.00*	*1.71*	*40.94*
NaOCl	*15.81*	*16.16*	*0.00*	*0.00*	*16.16*	*387.79*

Metering Pumps

	Stage 1		Stage 2	
	Gals/Hr	GPM	Gals/Hr	GPM
NaOH	*1.71*	*0.03*	*0.00*	*0.00*
NaOCl	*16.16*	*0.27*	*0.00*	*0.00*
H_2SO_4	*0.00*	*0.00*	*0.00*	*0.00*

Chemical Storage Tanks

NaOH	*1228*
NaOCl	*11634*
H_2SO_4	*0*

Blowdown Rate

	Amount	Solubility	GPM
NH_4SO_4	*0.00*	*71.00*	*0.00*
NaCl	*12.26*	*36.00*	*0.20*
Na_2SO_4	*7.46*	*19.00*	*0.24*
Evaporation	*10.00*		*7.00*
Total			*7.44*

Operating Costs

Electrical

	Fan	Recirculation Pumps				Chemical Metering Pumps			
		Acid		Alkaline		Acid		Alkaline	
		Stage 1	Stage 2	Stage 1	Stage 2	Stage 1	Stage 2	Stage 1	Stage 2
HP	*59.47*	*0.00*	*0.00*	*18.64*	*0.00*	*0*	*0.00*	*0.50*	*0.00*
Adjusted HP	*60.00*			*20.00*				*0.50*	
Kw-Hrs	*1074.24*	*0.00*	*0.00*	*358.08*	*0.00*	*0.00*	*0.00*	*8.95*	*0.00*
Cost	*$38*	*$0*	*$0*	*$13*	*$0*	*$0*	*$0*	*$0*	*$0*

Chemicals

	Acid		Alkaline			
	Stage 1	Stage 2	Stage 1		Stage 2	
			NaOH	NaOCl	NaOH	NaOCl
lbs/hr	*0.00*	*0.00*	*4.26*	*15.81*	*0.00*	*0.00*
Cost/day	*$0*	*$0*	*$46*	*$277*	*$0.00*	*$0.00*

Annual Cost

Labor	*$42,000*
Electrical	*$18,412*
Chemicals	*$118,016*
Total	*$178,428*

Scrubber Design
by
Huber Environmental, Inc.

Facility Information -		Nashville - Central	
Location		Alternative 5 ®	
Concentration		45	
Run Date -		4/29/2003	

Input Data

Selection of Parameters		(Use y for true, n for false)	**L'**	**G'**	**HTU/3.5**	**HTU/2**
NH_3	*n*	*Acid Scrubber Not Required*	*1024*	*492*	7	6
Mercapt*	*n*	*No Alkaline Scrubbing Required*	*5004*	*500*	32.2	28
H_2S	*y*	*Alkaline Scrubbing Will Be Required*	*1331*	*1229*	22	*19.4*

Recirculation Rates

Diameter	**GPM**
2	20
3	46
4	82
5	126
6	185
7	250
8	326
9	415
10	510
11	620
12	735

Safety Factor (%)		*20%*	**Oxidation**	
Stages	**(Acid)**		**None**	
Stages	**(Alkaline)**	*1*	**Partial**	
	Total	*1*	**Full**	**y**

Parameter Data

Parameter	Mole Weight	I - Conc (Avg)	I - Conc (Peak)	O - Conc (Avg)	O - Conc (Peak)	% Rem (Avg)	% Rem (Peak)
H_2S	*34*	*45*	*45*	*0.1*	*0.1*	*99.78%*	*99.78%*
Mercapt*	*62*					*0.00%*	*0.00%*
NH_3	*17*					*0.00%*	*0.00%*

* Add Molecular Weigh

Inlet Air Data

ACFM	Temp (F)	Air Density	CO_2	CO_2 Corr.	External Loss	Loss/Stage
34,500	*68*	*0.075*			*6*	*6*

Scrubbing Chemicals Data

Chemical	Mol. Wt	Sp. Gr	Conc. Factor	H_2S	Mercap	NH_3	Storage
A - NaOH	*40*	*10*	*25%*	*2.4*	*0.65*		*30*
B - NaOCl	*74.4*	*7.83*	*12.5%*	*8.9*	*3.6*		*30*
C - H_2SO_4	*98*	*8*	*93%*			*2.88*	*30*

Cost Data

	Electrical	A	B	C	Labor
	$0.035	*$0.45*	*$0.73*	*$1.00*	*$1.00*

Scrubber Design

Acid Stage		**Skip This Section**							
Gas #/Hr	Velocity	Tank Dia	Adj. Tk Dia.	Adj. Vel	Tank Area	NOG(Req)	Packing Size	Flow Rate	L'
155250		*0.00*		*0.00*	*0.00*	*0.00*			*0*
Des. Flow	L	L(Cor)	G'	Des Air	G	G(Cor)	HTU	HTU(Cor)	Z(Req)
0.00	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.000*	*0.00*
Z(Fin)	Depth/Stage	Set Depth	Z (Tot)	NOG(Fin)	NOG(1)	NOG(2)			
0.00	*0.00*		*0*	*0.00*	0.00	0.00			

Scrubber Design
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Alkaline Stage(s)												
Mercaptan		**Skip This Section and Go To H2S**										
Gas #/Hr	Velocity	Tank Dia	Adj. Tk Dia.	Final Tank Dia.	Final Velocity	Tank Area	NOG(Req)	Packing Size	Flow Rate			
155250.0	*500.00*	*0.00*		*10.0*	*0.00*	*78.50*	*0.00*					
L'	Des. Flow	L	L(Cor)	G'	Des Air	G	G(Cor)	HTU	HTU(Cor)			
0	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*			
Z(Req)	Z(Fin)	Depth/Stage	Set Depth	Z(Prelim)	Z(Final)	NOG(Fin)	NOG(1)	NOG(2)				
0.00	*0.00*	*0.00*		*0*	*0*	*0.00*	*0.00*	*0.00*				
H_2S												
Gas #/Hr	Velocity	Tank Dia	Adj. Tk Dia.	Final Tank Dia.	Final Velocity	Tank Area	NOG(Req)	Packing Size	Flow Rate			
155250.00	*500.00*	*9.38*	*10.00*	*10.00*	*439.49*	*78.50*	*6.11*	*3.50*	*510.0*			
Des. Flow	L	L(Cor)	G'	Des Air	G	G(Cor)	HTU	HTU(Cor)	Z(Req)			
208.80	*3251.01*	*0.74*	*1229.00*	*21439.22*	*1977.71*	*1.10*	*1.83*	*1.50*	*9.14*			
L'	Z(Fin)	Depth/Stage	Set Depth	Z(Prelim)	Z(Final)	NOG(Fin)	NOG(1)	NOG(2)				
1331.00	*10.97*	*10.97*	*10.00*	*10*	*10*	*6.68*	*6.68*	*0.00*				
Final												
Acid												
Tank Dia	Tank Area	Velocity	Z	Flow Rate	*Stages*							
0.00	*0.00*	*0.00*	*0*	*0*	*0*							
Alkaline												
Tank Dia	Tank Area	Velocity	Z	Flow Rate	Stages							
10.00	*78.50*	*439.49*	*10*	*510*	*1*							
NH3												
					Average							
		Stage 1			Stage 2				Total			
Inlet	Outlet	Lbs/Hr	% Removal	Inlet	Outlet	Lbs/Hr	% Removal	Lbs/Hr	% Removal	% Removal (Corr.)		
0.00	*0.00*	*0.00*	*0.00%*	*0.00*	*0.00*	*0.00*	*0.00%*	*0.00*	*0.00%*	*0.00%*		
					Peak							
		Stage 1			Stage 2				Total			
Inlet	Outlet	Lbs/Hr	% Removal	Inlet	Outlet	Lbs/Hr	% Removal	Lbs/Hr	% Removal	% Removal (Corr.)		
0.00	*0.00*	*0.00*	*0.00%*	*0.00*	*0.00*	*0.00*	*0.00%*	*0.00*	*0.00%*	*0.00%*		
H_2S												
					Average							
		Stage 1			Stage 2				Total			
Inlet	Outlet	Lbs/Hr	% Removal	Inlet	Outlet	Lbs/Hr	% Removal	Lbs/Hr	% Removal	% Removal (Corr.)		
45.00	*0.06*	*8.21*	*99.87%*	*0.00*	*0.00*	*0.00*	*0.00%*	*8.21*	*99.87%*	*99.87%*		
					Peak							
		Stage 1			Stage 2				Total			
Inlet	Outlet	Lbs/Hr	% Removal	Inlet	Outlet	Lbs/Hr	% Removal	Lbs/Hr	% Removal	% Removal (Corr.)		
45.00	*0.06*	*8.21*	*99.87%*	*0.00*	*0.00*	*0.00*	*0.00%*	*8.21*	*99.87%*	*99.87%*		
Mercaptan												
					Average							
		Stage 1			Stage 2				Total			
Inlet	Outlet	Lbs/Hr	% Removal	Inlet	Outlet	Lbs/Hr	% Removal	Lbs/Hr	% Removal	% Removal (Corr.)		
0.00	*0.00*	*0.00*	0.00%	*0.00*	*0.00*	*0.00*	*0.00%*	*0.00*	*0.00%*	*0.00%*		
					Peak							
		Stage 1			Stage 2				Total			
Inlet	Outlet	Lbs/Hr	% Removal	Inlet	Outlet	Lbs/Hr	% Removal	Lbs/Hr	% Removal	% Removal (Corr.)		
0.00	*0.00*	*0.00*	0.00%	*0.00*	*0.00*	*0.00*	0.00%	*0.00*	*0.00%*	*0.00%*		

Scrubber Design
by
Huber Environmental, Inc.

Output Data

Chemical Usage

Acid

	Average					
	Stage 1		Stage 2		Total	
	Lbs/Hr	Gal/Hr	Lbs/Hr	Gal/Hr	Gal/Hr	Gal/Day
H_2SO_4	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*

	Peak					
	Stage 1		Stage 2		Total	
	Lbs/Hr	Gal/Hr	Lbs/Hr	Gal/Hr	Gal/Hr	Gal/Day
H_2SO_4	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*

Alkaline

	Average					
	Stage 1		Stage 2		Total	
	Lbs/Hr	Gal/Hr	Lbs/Hr	Gal/Hr	Gal/Hr	Gal/Day
NaOH	*19.70*	*7.88*	*0.00*	*0.00*	*7.88*	*189.16*
NaOCl	*73.07*	*74.66*	*0.00*	*0.00*	*74.66*	*1791.78*

	Peak					
	Stage 1		Stage 2		Total	
	Lbs/Hr	Gal/Hr	Lbs/Hr	Gal/Hr	Gal/Hr	Gal/Day
NaOH	*19.70*	*7.88*	*0.00*	*0.00*	*7.88*	*189.16*
NaOCl	*73.07*	*74.66*	*0.00*	*0.00*	*74.66*	*1791.78*

Metering Pumps

	Stage 1		Stage 2	
	Gals/Hr	GPM	Gals/Hr	GPM
NaOH	*7.88*	*0.13*	*0.00*	*0.00*
NaOCl	*74.66*	*1.24*	*0.00*	*0.00*
H_2SO_4	*0.00*	*0.00*	*0.00*	*0.00*

Chemical Storage Tanks			**Blowdown Rate**			
				Amount	Solubility	GPM
NaOH	*5675*		NH_4SO_4	*0.00*	*71.00*	*0.00*
NaOCl	*53753*		NaCl	*56.65*	*36.00*	*0.94*
H_2SO_4	*0*		Na_2SO_4	*34.48*	*19.00*	*1.09*
			Evaporation	*10.00*		*5.75*
			Total			*7.78*

Operating Costs

Electrical

	Fan	Recirculation Pumps				Chemical Metering Pumps			
		Acid		Alkaline		Acid		Alkaline	
		Stage 1	Stage 2	Stage 1	Stage 2	Stage 1	Stage 2	Stage 1	Stage 2
HP	*48.85*	*0.00*	*0.00*	*15.33*	*0.00*	*0*	*0.00*	*0.50*	*0.00*
Adjusted HP	*50.00*			*20.00*				*0.50*	
Kw-Hrs	*895.20*	*0.00*	*0.00*	*358.08*	*0.00*	*0.00*	*0.00*	*8.95*	*0.00*
Cost	*$31*	*$0*	*$0*	*$13*	*$0*	*$0*	*$0*	*$0*	*$0*

Chemicals

	Acid		Alkaline			
	Stage 1	Stage 2	Stage 1		Stage 2	
			NaOH	NaOCl	NaOH	NaOCl
lbs/hr	*0.00*	*0.00*	*19.70*	*73.07*	*0.00*	*0.00*
Cost/day	*$0*	*$0*	*$214*	*$1,280*	*$0.00*	*$0.00*

Annual Cost

Labor	*$34,500*
Electrical	*$16,125*
Chemicals	*$545,294*
Total	*$595,919*

Scrubber Design
by
Huber Environmental, Inc.

Facility Information -		Nashville - Central	
Location		Alternative 7	
Concentration		30	
Run Date -		4/29/2003	

Input Data

Selection of Parameters		(Use y for true, n for false)		**L'**	**G'**	**HTU/3.5**	**HTU/2**
NH_3	*n*	*Acid Scrubber Not Required*		*1024*	*492*	7	*6*
Mercapt*	*n*	*No Alkaline Scrubbing Required*		*5004*	*500*	32.2	*28*
H_2S	*y*	*Alkaline Scrubbing Will Be Required*		*1331*	*1229*	22	*19.4*

Recirculation Rates

Diameter	**GPM**
2	20
3	46
4	82
5	126
6	185
7	250
8	326
9	415
10	510
11	620
12	735

Safety Factor (%)		*20%*	**Oxidation**	
Stages	**(Acid)**		**None**	
Stages	**(Alkaline)**	*1*	**Partial**	
	Total	*1*	**Full**	**y**

Parameter Data

Parameter	Mole Weight	I - Conc (Avg)	I - Conc (Peak)	O - Conc (Avg)	O - Conc (Peak)	% Rem (Avg)	% Rem (Peak)
H_2S	*34*	*30*	*30*	*0.1*	*0.1*	*99.67%*	*99.67%*
Mercapt*	*62*					*0.00%*	*0.00%*
NH_3	*17*					*0.00%*	*0.00%*

* Add Molecular Weigh

Inlet Air Data

ACFM	Temp (F)	Air Density	CO_2	CO_2 Corr.	External Loss	Loss/Stage
16,000	*68*	*0.075*			*6*	*6*

Scrubbing Chemicals Data

Chemical	Mol. Wt	Sp. Gr	Conc. Factor	H_2S	Mercap	NH_3	Storage
A - NaOH	*40*	*10*	*25%*	*2.4*	*0.65*		*30*
B - NaOCl	*74.4*	*7.83*	*12.5%*	*8.9*	*3.6*		*30*
C - H_2SO_4	*98*	*8*	*93%*			*2.88*	*30*

Cost Data

	Electrical	A	B	C	Labor
	$0.035	*$0.45*	*$0.73*	*$1.00*	*$1.00*

Scrubber Design

Acid Stage		**Skip This Section**							
Gas #/Hr	Velocity	Tank Dia	Adj. Tk Dia.	Adj. Vel	Tank Area	NOG(Req)	Packing Size	Flow Rate	L'
72000		*0.00*		*0.00*	*0.00*	*0.00*			*0*
Des. Flow	L	L(Cor)	G'	Des Air	G	G(Cor)	HTU	HTU(Cor)	Z(Req)
0.00	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.000*	*0.00*
Z(Fin)	Depth/Stage	Set Depth	Z (Tot)	NOG(Fin)	NOG(1)	NOG(2)			
0.00	*0.00*		*0*	*0.00*	0.00	0.00			

Scrubber Design

by

Huber Environmental, Inc.

Alkaline Stage(s)												
Mercaptan		**Skip This Section and Go To H2S**										
Gas #/Hr	Velocity	Tank Dia	Adj. Tk Dia.	Final Tank Dia.	Final Velocity	Tank Area	NOG(Req)	Packing Size	Flow Rate			
72000.0	500.00	0.00		6.0	0.00	28.26	0.00					
L'	Des. Flow	L	L(Cor)	G'	Des Air	G	G(Cor)	HTU	HTU(Cor)			
0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00			
Z(Req)	Z(Fin)	Depth/Stage	Set Depth	Z(Prelim)	Z(Final)	NOG(Fin)	NOG(1)	NOG(2)				
0.00	0.00	0.00		0	0	0.00	0.00	0.00				
H_2S												
Gas #/Hr	Velocity	Tank Dia	Adj. Tk Dia.	Final Tank Dia.	Final Velocity	Tank Area	NOG(Req)	Packing Size	Flow Rate			
72000.00	500.00	6.38	6.00	6.00	566.17	28.26	5.70	3.50	185.0			
Des. Flow	L	L(Cor)	G'	Des Air	G	G(Cor)	HTU	HTU(Cor)	Z(Req)			
75.17	3275.80	0.74	1229.00	7718.12	2547.77	1.16	1.83	1.57	8.96			
L'	Z(Fin)	Depth/Stage	Set Depth	Z(Prelim)	Z(Final)	NOG(Fin)	NOG(1)	NOG(2)				
1331.00	10.75	10.75	10.00	10	10	6.37	6.37	0.00				
Final												
Acid												
Tank Dia	Tank Area	Velocity	Z	Flow Rate	Stages							
0.00	0.00	0.00	0	0	0							
Alkaline												
Tank Dia	Tank Area	Velocity	Z	Flow Rate	Stages							
6.00	28.26	566.17	10	185	1							
NH3												
					Average							
		Stage 1			Stage 2				Total			
Inlet	Outlet	Lbs/Hr	% Removal	Inlet	Outlet	Lbs/Hr	% Removal	Lbs/Hr	% Removal	% Removal (Corr.)		
0.00	0.00	0.00	0.00%	0.00	0.00	0.00	0.00%	0.00	0.00%	0.00%		
					Peak							
		Stage 1			Stage 2				Total			
Inlet	Outlet	Lbs/Hr	% Removal	Inlet	Outlet	Lbs/Hr	% Removal	Lbs/Hr	% Removal	% Removal (Corr.)		
0.00	0.00	0.00	0.00%	0.00	0.00	0.00	0.00%	0.00	0.00%	0.00%		
H_2S												
					Average							
		Stage 1			Stage 2				Total			
Inlet	Outlet	Lbs/Hr	% Removal	Inlet	Outlet	Lbs/Hr	% Removal	Lbs/Hr	% Removal	% Removal (Corr.)		
30.00	0.05	2.54	99.83%	0.00	0.00	0.00	0.00%	2.54	99.83%	99.63%		
					Peak							
		Stage 1			Stage 2				Total			
Inlet	Outlet	Lbs/Hr	% Removal	Inlet	Outlet	Lbs/Hr	% Removal	Lbs/Hr	% Removal	% Removal (Corr.)		
30.00	0.05	2.54	99.83%	0.00	0.00	0.00	0.00%	2.54	99.83%	99.63%		
Mercaptan												
					Average							
		Stage 1			Stage 2				Total			
Inlet	Outlet	Lbs/Hr	% Removal	Inlet	Outlet	Lbs/Hr	% Removal	Lbs/Hr	% Removal	% Removal (Corr.)		
0.00	0.00	0.00	0.00%	0.00	0.00	0.00	0.00%	0.00	0.00%	0.00%		
					Peak							
		Stage 1			Stage 2				Total			
Inlet	Outlet	Lbs/Hr	% Removal	Inlet	Outlet	Lbs/Hr	% Removal	Lbs/Hr	% Removal	% Removal (Corr.)		
0.00	0.00	0.00	0.00%	0.00	0.00	0.00	0.00%	0.00	0.00%	0.00%		

Scrubber Design
by
Huber Environmental, Inc.

Output Data

Chemical Usage

Acid

Average

	Stage 1		Stage 2		Total	
	Lbs/Hr	Gal/Hr	Lbs/Hr	Gal/Hr	Gal/Hr	Gal/Day
H_2SO_4	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*

Peak

	Stage 1		Stage 2		Total	
	Lbs/Hr	Gal/Hr	Lbs/Hr	Gal/Hr	Gal/Hr	Gal/Day
H_2SO_4	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*

Alkaline

Average

	Stage 1		Stage 2		Total	
	Lbs/Hr	Gal/Hr	Lbs/Hr	Gal/Hr	Gal/Hr	Gal/Day
NaOH	*6.09*	*2.44*	*0.00*	*0.00*	*2.44*	*58.46*
NaOCl	*22.58*	*23.07*	*0.00*	*0.00*	*23.07*	*553.72*

Peak

	Stage 1		Stage 2		Total	
	Lbs/Hr	Gal/Hr	Lbs/Hr	Gal/Hr	Gal/Hr	Gal/Day
NaOH	*6.09*	*2.44*	*0.00*	*0.00*	*2.44*	*58.46*
NaOCl	*22.58*	*23.07*	*0.00*	*0.00*	*23.07*	*553.72*

Metering Pumps

	Stage 1		Stage 2	
	Gals/Hr	GPM	Gals/Hr	GPM
NaOH	*2.44*	*0.04*	*0.00*	*0.00*
NaOCl	*23.07*	*0.38*	*0.00*	*0.00*
H_2SO_4	*0.00*	*0.00*	*0.00*	*0.00*

Chemical Storage Tanks

NaOH	*1754*
NaOCl	*16612*
H_2SO_4	*0*

Blowdown Rate

	Amount	Solubility	GPM
NH_4SO_4	*0.00*	*71.00*	*0.00*
NaCl	*17.51*	*36.00*	*0.29*
Na_2SO_4	*10.66*	*19.00*	*0.34*
Evaporation	*10.00*		*2.67*
Total			*3.29*

Operating Costs

Electrical

	Fan	Recirculation Pumps				Chemical Metering Pumps			
		Acid		Alkaline		Acid		Alkaline	
		Stage 1	Stage 2	Stage 1	Stage 2	Stage 1	Stage 2	Stage 1	Stage 2
HP	*22.66*	*0.00*	*0.00*	*5.56*	*0.00*	*0*	*0.00*	*0.50*	*0.00*
Adjusted HP	*25.00*			*10.00*				*0.50*	
Kw-Hrs	*447.60*	*0.00*	*0.00*	*179.04*	*0.00*	*0.00*	*0.00*	*8.95*	*0.00*
Cost	*$16*	*$0*	*$0*	*$6*	*$0*	*$0*	*$0*	*$0*	*$0*

Chemicals

	Acid		Alkaline			
	Stage 1	Stage 2	Stage 1		Stage 2	
			NaOH	NaOCl	NaOH	NaOCl
lbs/hr	*0.00*	*0.00*	*6.09*	*22.58*	*0.00*	*0.00*
Cost/day	*$0*	*$0*	*$66*	*$396*	*$0.00*	*$0.00*

Annual Cost

Labor	*$16,000*
Electrical	*$8,120*
Chemicals	*$168,515*
Total	*$192,635*

Scrubber Design
by
Huber Environmental, Inc.

Facility Information -		Nashville - Central							
Location		Alternative 8							
Concentration		30							
Run Date -		4/29/2003							

Input Data

Selection of Parameters		(Use y for true, n for false)			**L'**	**G'**	**HTU/3.5**	**HTU/2**
NH_3	*n*	*Acid Scrubber Not Required*			*1024*	*492*	7	*6*
Mercapt*	*n*	*No Alkaline Scrubbing Required*			*5004*	*500*	32.2	*28*
H_2S	*y*	*Alkaline Scrubbing Will Be Required*			*1331*	*1229*	22	*19.4*

Recirculation Rates

Diameter	**GPM**
2	20
3	46
4	82
5	126
6	185
7	250
8	326
9	415
10	510
11	620
12	735

Safety Factor (%)		*20%*	**Oxidation**	
Stages	**(Acid)**		**None**	
Stages	**(Alkaline)**	*1*	**Partial**	
	Total	*1*	**Full**	**y**

Parameter Data

Parameter	Mole Weight	I - Conc (Avg)	I - Conc (Peak)	O - Conc (Avg)	O - Conc (Peak)	% Rem (Avg)	% Rem (Peak)
H_2S	*34*	*5*	*5*	*0.1*	*0.1*	*98.00%*	*98.00%*
Mercapt*	*62*					*0.00%*	*0.00%*
NH_3	*17*					*0.00%*	*0.00%*

* Add Molecular Weight

Inlet Air Data

ACFM	Temp (F)	Air Density	CO_2	CO_2 Corr.	External Loss	Loss/Stage
5,000	*68*	*0.075*			*6*	*6*

Scrubbing Chemicals Data

Chemical	Mol. Wt	Sp. Gr	Conc. Factor	H_2S	Mercap	NH_3	Storage
A - NaOH	*40*	*10*	*25%*	*2.4*	*0.65*		*30*
B - NaOCl	*74.4*	*7.83*	*12.5%*	*8.9*	*3.6*		*30*
C - H_2SO_4	*98*	*8*	*93%*			*2.88*	*30*

Cost Data

	Electrical	A	B	C	Labor
	$0.035	*$0.45*	*$0.73*	*$1.00*	*$1.00*

Scrubber Design

Acid Stage		**Skip This Section**							
Gas #/Hr	Velocity	Tank Dia	Adj. Tk Dia.	Adj. Vel	Tank Area	NOG(Req)	Packing Size	Flow Rate	L'
22500		*0.00*		*0.00*	*0.00*	*0.00*			*0*
Des. Flow	L	L(Cor)	G'	Des Air	G	G(Cor)	HTU	HTU(Cor)	Z(Req)
0.00	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.000*	*0.00*
Z(Fin)	Depth/Stage	Set Depth	Z (Tot)	NOG(Fin)	NOG(1)	NOG(2)			
0.00	*0.00*		*0*	*0.00*	0.00	0.00			

Scrubber Design
by
Huber Environmental, Inc.

Alkaline Stage(s)										
Mercaptan		**Skip This Section and Go To H2S**								
Gas #/Hr	Velocity	Tank Dia	Adj. Tk Dia.	Final Tank Dia.	Final Velocity	Tank Area	NOG(Req)	Packing Size	Flow Rate	
22500.0	500.00	0.00		4.0	0.00	12.56	0.00			
L'	Des. Flow	L	L(Cor)	G'	Des Air	G	G(Cor)	HTU	HTU(Cor)	
0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
Z(Req)	Z(Fin)	Depth/Stage	Set Depth	Z(Prelim)	Z(Final)	NOG(Fin)	NOG(1)	NOG(2)		
0.00	0.00	0.00		0	0	0.00	0.00	0.00		
H_2S										
Gas #/Hr	Velocity	Tank Dia	Adj. Tk Dia.	Final Tank Dia.	Final Velocity	Tank Area	NOG(Req)	Packing Size	Flow Rate	
22500.00	500.00	3.57	4.00	4.00	398.09	12.56	3.91	3.50	82.0	
Des. Flow	L	L(Cor)	G'	Des Air	G	G(Cor)	HTU	HTU(Cor)	Z(Req)	
33.41	3266.94	0.74	1229.00	3430.28	1791.40	1.08	1.83	1.46	5.73	
L'	Z(Fin)	Depth/Stage	Set Depth	Z(Prelim)	Z(Final)	NOG(Fin)	NOG(1)	NOG(2)		
1331.00	6.88	6.88	10.00	10	10	6.83	6.83	0.00		
Final										
Acid										
Tank Dia	Tank Area	Velocity	Z	Flow Rate	Stages					
0.00	0.00	0.00	0	0	0					
Alkaline										
Tank Dia	Tank Area	Velocity	Z	Flow Rate	Stages					
4.00	12.56	398.09	10	82	1					
NH3										
					Average					
		Stage 1			Stage 2				Total	
Inlet	Outlet	Lbs/Hr	% Removal	Inlet	Outlet	Lbs/Hr	% Removal	Lbs/Hr	% Removal	% Removal (Corr.)
0.00	0.00	0.00	0.00%	0.00	0.00	0.00	0.00%	0.00	0.00%	0.00%
					Peak					
		Stage 1			Stage 2				Total	
Inlet	Outlet	Lbs/Hr	% Removal	Inlet	Outlet	Lbs/Hr	% Removal	Lbs/Hr	% Removal	% Removal (Corr.)
0.00	0.00	0.00	0.00%	0.00	0.00	0.00	0.00%	0.00	0.00%	0.00%
H_2S										
					Average					
		Stage 1			Stage 2				Total	
Inlet	Outlet	Lbs/Hr	% Removal	Inlet	Outlet	Lbs/Hr	% Removal	Lbs/Hr	% Removal	% Removal (Corr.)
5.00	0.01	0.13	99.89%	0.00	0.00	0.00	0.00%	0.13	99.89%	99.89%
					Peak					
		Stage 1			Stage 2				Total	
Inlet	Outlet	Lbs/Hr	% Removal	Inlet	Outlet	Lbs/Hr	% Removal	Lbs/Hr	% Removal	% Removal (Corr.)
5.00	0.01	0.13	99.89%	0.00	0.00	0.00	0.00%	0.13	99.89%	99.89%
Mercaptan										
					Average					
		Stage 1			Stage 2				Total	
Inlet	Outlet	Lbs/Hr	% Removal	Inlet	Outlet	Lbs/Hr	% Removal	Lbs/Hr	% Removal	% Removal (Corr.)
0.00	0.00	0.00	0.00%	0.00	0.00	0.00	0.00%	0.00	0.00%	0.00%
					Peak					
		Stage 1			Stage 2				Total	
Inlet	Outlet	Lbs/Hr	% Removal	Inlet	Outlet	Lbs/Hr	% Removal	Lbs/Hr	% Removal	% Removal (Corr.)
0.00	0.00	0.00	0.00%	0.00	0.00	0.00	0.00%	0.00	0.00%	0.00%

Scrubber Design
by
Huber Environmental, Inc.

Output Data

Chemical Usage

Acid

	Average					
	Stage 1		Stage 2		Total	
	Lbs/Hr	Gal/Hr	Lbs/Hr	Gal/Hr	Gal/Hr	Gal/Day
H_2SO_4	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*

	Peak					
	Stage 1		Stage 2		Total	
	Lbs/Hr	Gal/Hr	Lbs/Hr	Gal/Hr	Gal/Hr	Gal/Day
H_2SO_4	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*

Alkaline

	Average					
	Stage 1		Stage 2		Total	
	Lbs/Hr	Gal/Hr	Lbs/Hr	Gal/Hr	Gal/Hr	Gal/Day
NaOH	*0.32*	*0.13*	*0.00*	*0.00*	*0.13*	*3.05*
NaOCl	*1.18*	*1.20*	*0.00*	*0.00*	*1.20*	*28.86*

	Peak					
	Stage 1		Stage 2		Total	
	Lbs/Hr	Gal/Hr	Lbs/Hr	Gal/Hr	Gal/Hr	Gal/Day
NaOH	*0.32*	*0.13*	*0.00*	*0.00*	*0.13*	*3.05*
NaOCl	*1.18*	*1.20*	*0.00*	*0.00*	*1.20*	*28.86*

Metering Pumps

	Stage 1		Stage 2	
	Gals/Hr	GPM	Gals/Hr	GPM
NaOH	*0.13*	*0.00*	*0.00*	*0.00*
NaOCl	*1.20*	*0.02*	*0.00*	*0.00*
H_2SO_4	*0.00*	*0.00*	*0.00*	*0.00*

Chemical Storage Tanks

		Blowdown Rate			
			Amount	Solubility	GPM
NaOH	*91*	NH_4SO_4	*0.00*	*71.00*	*0.00*
NaOCl	*866*	NaCl	*0.91*	*36.00*	*0.02*
H_2SO_4	*0*	Na_2SO_4	*0.56*	*19.00*	*0.02*
		Evaporation	*10.00*		*0.83*
		Total			*0.87*

Operating Costs

Electrical

	Fan	Recirculation Pumps				Chemical Metering Pumps			
		Acid		Alkaline		Acid		Alkaline	
		Stage 1	Stage 2	Stage 1	Stage 2	Stage 1	Stage 2	Stage 1	Stage 2
HP	*7.08*	*0.00*	*0.00*	*2.47*	*0.00*	*0*	*0.00*	*0.50*	*0.00*
Adjusted HP	*10.00*			*5.00*				*0.50*	
Kw-Hrs	*179.04*	*0.00*	*0.00*	*89.52*	*0.00*	*0.00*	*0.00*	*8.95*	*0.00*
Cost	*$6*	*$0*	*$0*	*$3*	*$0*	*$0*	*$0*	*$0*	*$0*

Chemicals

	Acid		Alkaline			
	Stage 1	Stage 2	Stage 1		Stage 2	
			NaOH	NaOCl	NaOH	NaOCl
lbs/hr	*0.00*	*0.00*	*0.32*	*1.18*	*0.00*	*0.00*
Cost/day	*$0*	*$0*	*$3*	*$21*	*$0.00*	*$0.00*

Annual Cost

Labor	*$5,000*
Electrical	*$3,545*
Chemicals	*$8,782*
Total	*$17,328*

Scrubber Design
by
Huber Environmental, Inc.

Facility Information -		Nashville - Central						
Location		Alternative 9						
Concentration		24						
Run Date -		4/29/2003						

Input Data

Selection of Parameters		(Use y for true, n for false)		**L'**	**G'**	**HTU/3.5**	**HTU/2**
NH_3	*n*	*Acid Scrubber Not Required*		*1024*	*492*	7	6
Mercapt*	*n*	*No Alkaline Scrubbing Required*		*5004*	*500*	32.2	28
H_2S	*y*	*Alkaline Scrubbing Will Be Required*		*1331*	*1229*	22	*19.4*

Recirculation Rates

Diameter	**GPM**
2	20
3	46
4	82
5	126
6	185
7	250
8	326
9	415
10	510
11	620
12	735

Safety Factor (%)		*20%*	**Oxidation**	
Stages	**(Acid)**		**None**	
Stages	**(Alkaline)**	*1*	**Partial**	
	Total	*1*	**Full**	**y**

Parameter Data

Parameter	Mole Weight	I - Conc (Avg)	I - Conc (Peak)	O - Conc (Avg)	O - Conc (Peak)	% Rem (Avg)	% Rem (Peak)
H_2S	*34*	*24*	*24*	*0.1*	*0.1*	*99.58%*	*99.58%*
Mercapt*	*62*					*0.00%*	*0.00%*
NH_3	*17*					*0.00%*	*0.00%*

* Add Molecular Weigh

Inlet Air Data

ACFM	Temp (F)	Air Density	CO_2	CO_2 Corr.	External Loss	Loss/Stage
21,000	*68*	*0.075*			*6*	*6*

Scrubbing Chemicals Data

Chemical	Mol. Wt	Sp. Gr	Conc. Factor	H_2S	Mercap	NH_3	Storage
A - NaOH	*40*	*10*	*25%*	*2.4*	*0.65*		*30*
B - NaOCl	*74.4*	*7.83*	*12.5%*	*8.9*	*3.6*		*30*
C - H_2SO_4	*98*	*8*	*93%*			*2.88*	*30*

Cost Data

	Electrical	A	B	C	Labor
	$0.035	*$0.45*	*$0.73*	*$1.00*	*$1.00*

Scrubber Design

Acid Stage		**Skip This Section**							
Gas #/Hr	Velocity	Tank Dia	Adj. Tk Dia.	Adj. Vel	Tank Area	NOG(Req)	Packing Size	Flow Rate	L'
94500		*0.00*		*0.00*	*0.00*	*0.00*			*0*
Des. Flow	L	L(Cor)	G'	Des Air	G	G(Cor)	HTU	HTU(Cor)	Z(Req)
0.00	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.000*	*0.00*
Z(Fin)	Depth/Stage	Set Depth	Z (Tot)	NOG(Fin)	NOG(1)	NOG(2)			
0.00	*0.00*		*0*	*0.00*	0.00	0.00			

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Alkaline Stage(s)										
Mercaptan		**Skip This Section and Go To H2S**								
Gas #/Hr	Velocity	Tank Dia	Adj. Tk Dia.	Final Tank Dia.	Final Velocity	Tank Area	NOG(Req)	Packing Size	Flow Rate	
94500.0	*500.00*	*0.00*		*7.0*	*0.00*	*38.47*	*0.00*			
L'	Des. Flow	L	L(Cor)	G'	Des Air	G	G(Cor)	HTU	HTU(Cor)	
0	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	
Z(Req)	Z(Fin)	Depth/Stage	Set Depth	Z(Prelim)	Z(Final)	NOG(Fin)	NOG(1)	NOG(2)		
0.00	*0.00*	*0.00*		*0*	*0*	*0.00*	*0.00*	*0.00*		
H_2S										
Gas #/Hr	Velocity	Tank Dia	Adj. Tk Dia.	Final Tank Dia.	Final Velocity	Tank Area	NOG(Req)	Packing Size	Flow Rate	
94500.00	*500.00*	*7.31*	*7.00*	*7.00*	*545.95*	*38.47*	*5.48*	*3.50*	*250.0*	
Des. Flow	L	L(Cor)	G'	Des Air	G	G(Cor)	HTU	HTU(Cor)	Z(Req)	
102.31	*3252.31*	*0.74*	*1229.00*	*10505.22*	*2456.78*	*1.15*	*1.83*	*1.56*	*8.56*	
L'	Z(Fin)	Depth/Stage	Set Depth	Z(Prelim)	Z(Final)	NOG(Fin)	NOG(1)	NOG(2)		
1331.00	*10.28*	*10.28*	*10.00*	*10*	*10*	*6.40*	*6.40*	*0.00*		
Final										
Acid										
Tank Dia	Tank Area	Velocity	Z	Flow Rate	*Stages*					
0.00	*0.00*	*0.00*	*0*	*0*	*0*					
Alkaline										
Tank Dia	Tank Area	Velocity	Z	Flow Rate	Stages					
7.00	*38.47*	*545.95*	*10*	*250*	*1*					
NH3										
					Average					
		Stage 1			Stage 2				Total	
Inlet	Outlet	Lbs/Hr	% Removal	Inlet	Outlet	Lbs/Hr	% Removal	Lbs/Hr	% Removal	% Removal (Corr.)
0.00	*0.00*	*0.00*	*0.00%*	*0.00*	*0.00*	*0.00*	*0.00%*	*0.00*	*0.00%*	*0.00%*
					Peak					
		Stage 1			Stage 2				Total	
Inlet	Outlet	Lbs/Hr	% Removal	Inlet	Outlet	Lbs/Hr	% Removal	Lbs/Hr	% Removal	% Removal (Corr.)
0.00	*0.00*	*0.00*	*0.00%*	*0.00*	*0.00*	*0.00*	*0.00%*	*0.00*	*0.00%*	*0.00%*
H_2S										
					Average					
		Stage 1			Stage 2				Total	
Inlet	Outlet	Lbs/Hr	% Removal	Inlet	Outlet	Lbs/Hr	% Removal	Lbs/Hr	% Removal	% Removal (Corr.)
24.00	*0.04*	*2.66*	*99.83%*	*0.00*	*0.00*	*0.00*	*0.00%*	*2.66*	*99.83%*	*99.73%*
					Peak					
		Stage 1			Stage 2				Total	
Inlet	Outlet	Lbs/Hr	% Removal	Inlet	Outlet	Lbs/Hr	% Removal	Lbs/Hr	% Removal	% Removal (Corr.)
24.00	*0.04*	*2.66*	*99.83%*	*0.00*	*0.00*	*0.00*	*0.00%*	*2.66*	*99.83%*	*99.73%*
Mercaptan										
					Average					
		Stage 1			Stage 2				Total	
Inlet	Outlet	Lbs/Hr	% Removal	Inlet	Outlet	Lbs/Hr	% Removal	Lbs/Hr	% Removal	% Removal (Corr.)
0.00	*0.00*	*0.00*	0.00%	*0.00*	*0.00*	*0.00*	*0.00%*	*0.00*	*0.00%*	*0.00%*
					Peak					
		Stage 1			Stage 2				Total	
Inlet	Outlet	Lbs/Hr	% Removal	Inlet	Outlet	Lbs/Hr	% Removal	Lbs/Hr	% Removal	% Removal (Corr.)
0.00	*0.00*	*0.00*	0.00%	*0.00*	*0.00*	*0.00*	0.00%	*0.00*	*0.00%*	*0.00%*

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Output Data

Chemical Usage

Acid

	Average					
	Stage 1		Stage 2		Total	
	Lbs/Hr	Gal/Hr	Lbs/Hr	Gal/Hr	Gal/Hr	Gal/Day
H_2SO_4	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*

	Peak					
	Stage 1		Stage 2		Total	
	Lbs/Hr	Gal/Hr	Lbs/Hr	Gal/Hr	Gal/Hr	Gal/Day
H_2SO_4	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*

Alkaline

	Average					
	Stage 1		Stage 2		Total	
	Lbs/Hr	Gal/Hr	Lbs/Hr	Gal/Hr	Gal/Hr	Gal/Day
NaOH	*6.39*	*2.56*	*0.00*	*0.00*	*2.56*	*61.38*
NaOCl	*23.71*	*24.23*	*0.00*	*0.00*	*24.23*	*581.44*

	Peak					
	Stage 1		Stage 2		Total	
	Lbs/Hr	Gal/Hr	Lbs/Hr	Gal/Hr	Gal/Hr	Gal/Day
NaOH	*6.39*	*2.56*	*0.00*	*0.00*	*2.56*	*61.38*
NaOCl	*23.71*	*24.23*	*0.00*	*0.00*	*24.23*	*581.44*

Metering Pumps

	Stage 1		Stage 2	
	Gals/Hr	GPM	Gals/Hr	GPM
NaOH	*2.56*	*0.04*	*0.00*	*0.00*
NaOCl	*24.23*	*0.40*	*0.00*	*0.00*
H_2SO_4	*0.00*	*0.00*	*0.00*	*0.00*

Chemical Storage Tanks

Chemical Storage Tanks			Blowdown Rate		
			Amount	Solubility	GPM
NaOH	*1842*	NH_4SO_4	*0.00*	*71.00*	*0.00*
NaOCl	*17443*	NaCl	*18.38*	*36.00*	*0.31*
H_2SO_4	*0*	Na_2SO_4	*11.19*	*19.00*	*0.35*
		Evaporation	*10.00*		*3.50*
		Total			*4.16*

Operating Costs

Electrical

	Fan	Recirculation Pumps				Chemical Metering Pumps			
		Acid		Alkaline		Acid		Alkaline	
		Stage 1	Stage 2	Stage 1	Stage 2	Stage 1	Stage 2	Stage 1	Stage 2
HP	*29.74*	*0.00*	*0.00*	*7.52*	*0.00*	*0*	*0.00*	*0.50*	*0.00*
Adjusted HP	*30.00*			*10.00*				*0.50*	
Kw-Hrs	*537.12*	*0.00*	*0.00*	*179.04*	*0.00*	*0.00*	*0.00*	*8.95*	*0.00*
Cost	*$19*	*$0*	*$0*	*$6*	*$0*	*$0*	*$0*	*$0*	*$0*

Chemicals

	Acid		Alkaline			
	Stage 1	Stage 2	Stage 1		Stage 2	
			NaOH	NaOCl	NaOH	NaOCl
lbs/hr	*0.00*	*0.00*	*6.39*	*23.71*	*0.00*	*0.00*
Cost/day	*$0*	*$0*	*$69*	*$415*	*$0.00*	*$0.00*

Annual Cost

Labor	*$21,000*
Electrical	*$9,263*
Chemicals	*$176,950*
Total	*$207,214*